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The Coast and Geodetic Survey Tide Predicting Machine No. 2.

By E. G. FISCHER.*

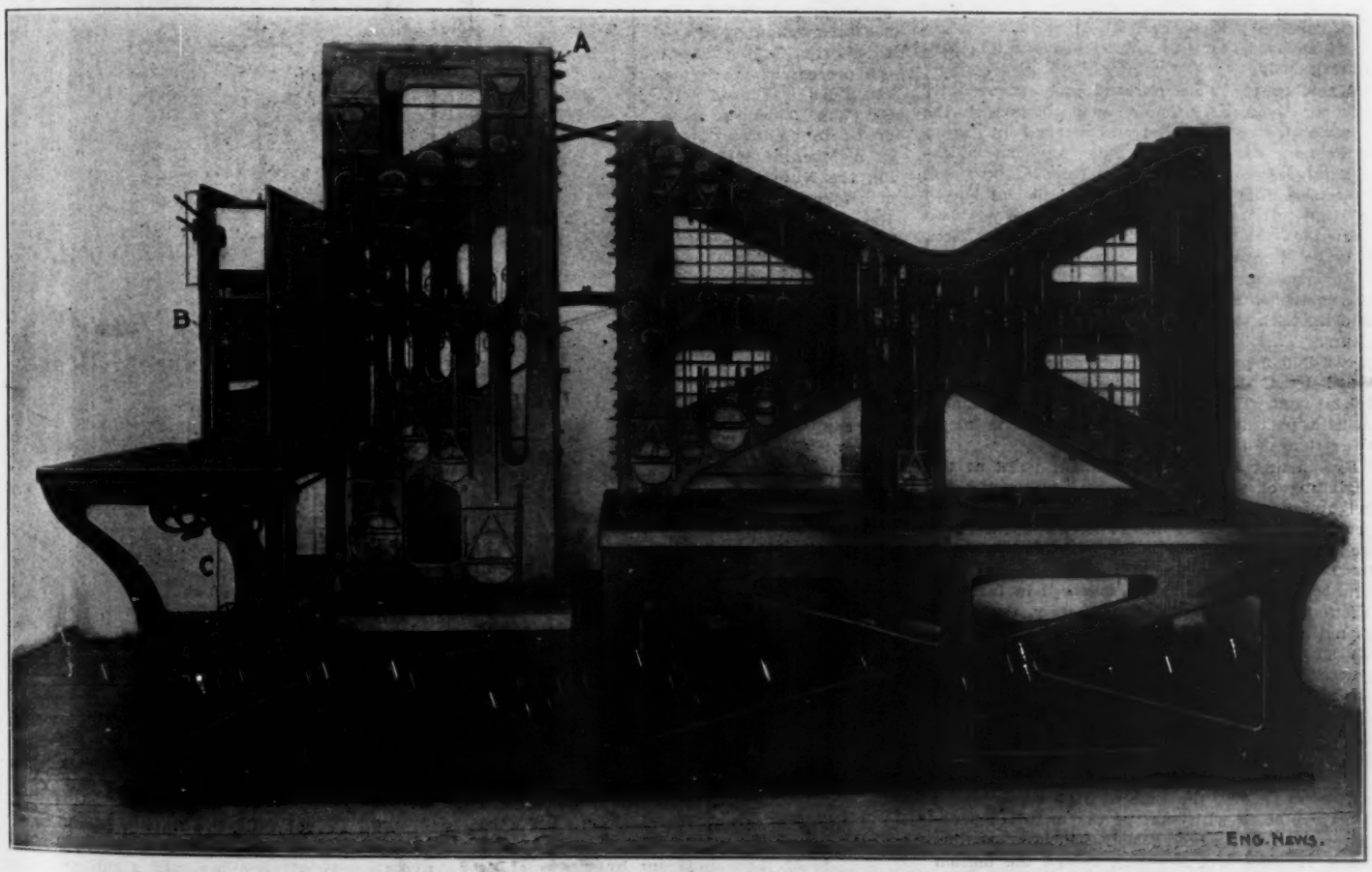
One of the important functions of the Coast and Geodetic Survey is the preparation and publication of a tidal calendar, issued annually from one or two years in advance, under the name of "Tide Tables." These tables give the mariner, the engineer, and numerous others interested, information as to the time and magnitude of the tidal fluctuations of the sea. They show directly the time to the minute and the height to the nearest tenth of a foot of every high and low water in the year at 70 principal sea ports of the world; and give indirectly, by means of an appended auxiliary table, the same information for more than 3,000 intermediate ports or stations.

*Chief, Instrument Division, Coast and Geodetic Survey, Washington, D. C.

Theory of the Tides.

While the civil calendar deals only with the positions of the important heavenly bodies, the preparation of the data for a tidal calendar involves also a knowledge of the effect upon the sea due to the force of attraction of the moon and sun. The laws governing the motion of liquid bodies under the influence of the force of attraction is well known; the tides upon a sphere covered completely by water of uniform depth could be foretold from astronomical data alone. But the continents, islands and the great difference in the depths of the oceans prevent such ideal tides, as regards both time and magnitude; so that it is necessary to resort to observation in order to ascertain the elements characteristic of each station, before the height and time of future tides can be computed.

These observations are made mainly by means of automatic recording tide gages, in which the rise and fall of the water is made to move a pencil back and forth across a strip of paper; the latter being kept moving at uniform speed, by clockwork, thus producing a continuous tide curve.



C. & G. SURVEY TIDE PREDICTING MACHINE NO. 2: TIME SIDE.

A. Main Driving Shaft. B. Height Chain. C. Time Chain.

Owing to the extremely complicated nature of the motions of the moon and earth, it was practically impossible to take account of more than the most important elements in predicting tides, until there was devised, about 1867, by Sir Wm. Thomson (later Lord Kelvin) a system for the reduction of tides known as "harmonic analysis." This system assumes, in the place of the apparent

sun with varying speed in an elliptical orbit inclined to the equator about 23½°, a fictitious or theoretical sun moving with uniform speed in a circular orbit in the plane of the equator, and likewise, for the real moon, which moves with varying speed in an elliptical orbit inclined about 5° to the ecliptic, a theoretical moon with uniform speed in a circular orbit also in the equatorial plane. It further provides for additional imaginary bodies or components, each with its own uniform speed and period of revolution, so designed that the whole, when combined in proper relations to each other, will represent accurately the very complex motions of the real sun and moon.

All the important ones of these theoretical bodies or components were carefully determined by Sir Wm. Thomson and published in a table, later extended and improved by Sir Geo. H. Darwin, in which their speeds are expressed in degrees and fractions to the seventh decimal per mean solar hour. Each component is known by a symbol of a system of notation adopted for the sake of convenience. This table has since been used the world over by all who have to deal with tidal computations.

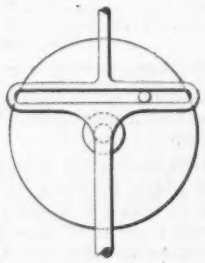


Fig. 1.

As these components, properly applied to the theoretical mean sun and moon, practically correct their regular but incorrect motions to the irregular actual motions of the real sun and moon, they also act as correctives to the forces represented by them, and it is permissible to regard each of them as an independent tide producing body.

Knowing the time element and consequently the period of revolution of each component, the complicated curve traced and marked into mean solar hour spaces by the tide gage can be decomposed into its harmonic elements; provided, of course, that it extend over a sufficient length of time, desirably not less than one year, so that the effects of wind storms, freshets, etc., may be eliminated.

For convenience the periods of revolution of the components are regarded as component days, and the 24th parts of these periods as component hours. The length of the component day, expressed in mean solar time, is equal to 360° divided by the hourly speed of the component, taken from Thomson's table above mentioned. A 24th part is, of course, the length in mean solar time of the component hour.

By starting from any convenient point at the beginning of the tide curve and measuring the heights of the tide throughout its length of a year or more at intervals of a component hour, we obtain all the heights at the first, second, third and so on to the 24th hour. These readings reduced to 24 means, expressed in feet and fractions, represent quite accurately the effect upon the sea due to the particular component at the station where the curve was made. In a general sense, these 24 hourly means may be regarded as representing a component tide curve. The semi-range of this curve or the height above mean sea level, is called the "amplitude" of the component, and is a constant for that station.

Were the effects of the tidal forces upon the sea instantaneous, the time of high water would always coincide with that of the meridian passage of the tide producing body. Inertia, friction, bodies of land, etc., however, retard the motion of the tidal wave, and unequally so, at different stations. The lagging of an observed high water behind the time when the tide producing cause is in the meridian may also be considered as the effect of the combined laggings of all the individual components behind their respective meridian passages. To find the lag of a component, therefore, it is only necessary to determine the time from the highest point on the curve, expressed by the 24 hourly means, to the instant of the meridian passage of the component. This time, expressed in degrees of arc, is called the "epoch" and is, like the amplitude, a constant for the component at the station.

The amplitudes and epochs of the components entering into the tides have been determined by this analysis for practically all the important stations in the world, and have become, like astronomical data, through courtesy, exchange and publication, common property. With their aid the tides can now be computed in advance by the summation:

$$H_0 + A \cos(a\,t + \alpha) + B \cos(b\,t + \beta) + C \cos(c\,t + \gamma) + \ldots,$$

in which H_0 is a constant expressing the height of mean sea level above the datum line, which usually represents the plane to which the soundings given on sailing charts are referred. $A, B, C \ldots$ are the amplitudes of the successive components, expressed in feet and fractions, and $a, b, c \ldots$ the hourly speeds of the same components, expressed in degrees of arc; t is the time in mean solar hours from the beginning of the prediction, usually Jan. 1, midnight, to the instant for which the height is required. α is the interval from the first high water of the component A, back to the beginning of the prediction, expressed in degrees; $\beta, \gamma \ldots$ being like intervals for the components $B, C \ldots$.

The First Tide Predicting Machine.

Although the application of harmonic analysis to tide observations made it possible to take into account all the principal and minor components, the combination of the component elements for predicting the tides still involved a great amount of methodical work, so that the need of mechanical means to shorten and cheapen the process of predicting the tides was soon felt. Sir Wm. Thomson gave credit to "A Description of a Machine for Finding the Numerical Roots of Equations," by the Rev. F. Bashford, read before the British Association in 1845, for suggesting to him a method of summing mechanically the series expressing the tidal fluctuations of the sea; and he designed and had made in 1876 under the auspices of the British Association, the first machine for computing the tides. It provides for ten components and was called by him the British Association Tide Predicting Machine. It was used but little, and later deposited in the Kensington Museum, where it now is.

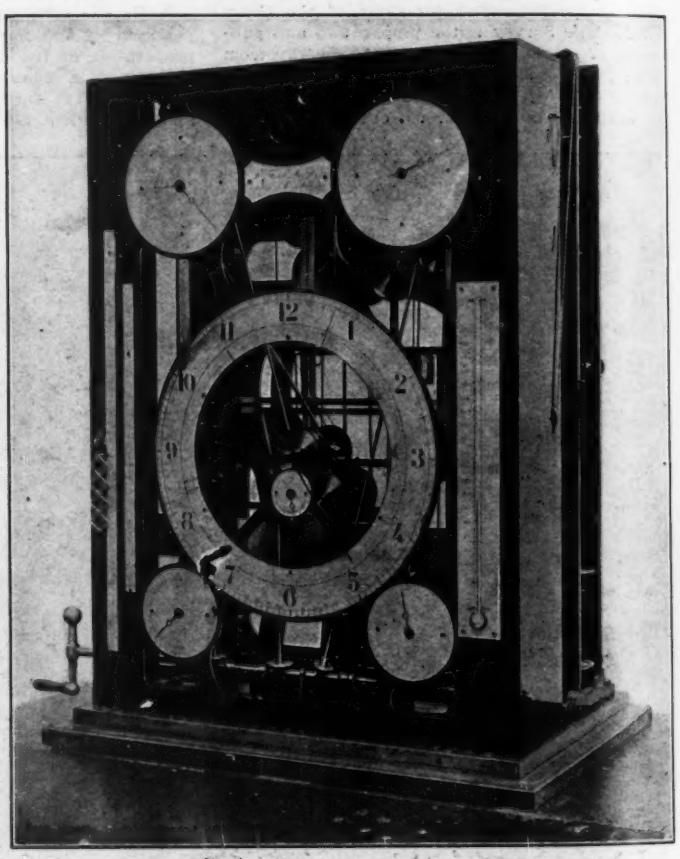


FIG. 2. FERREL TIDE PREDICTING MACHINE.

The method of summing used in this machine is that of a flexible wire or chain fastened at one end and passed over and under pulleys representing the ten components; each pulley is mounted on a crank of a shaft. The eccentricity of each crank represents the amplitude of one of the components. Each shaft is caused to rotate in periods of the component by means of gear wheels connected to a driving shaft common to all. The cranks are adjustable on their shafts and can be clamped in proper angular relation to each other according to their epochs. The turning of the driving shaft causes the pulleys to raise or lower the free end of the chain, which, provided with a suitable pen resting upon a strip of paper moving laterally at uniform speed, traces a curve representing the tidal fluctuations of the sea at the place and time for which the components were set. This method of summation has been used in all the tide predicting machines constructed since. An improvement in the arrangement of the pulleys was suggested by Sir Wm. Thomson, which several years later was used in the construction of a second tide predicting machine, made for the Government of India, under the direction of Mr. E. Roberts of the Nautical Almanac Office. In this machine the component pulleys, instead of rotating on cranks in circles with radii equal to the amplitudes, are made to rise and fall in true linear harmonic motion, by means of the mechanical device, known as the "slotted yoke crank motion." (See Fig. 1.) This machine, generally known as the Roberts Tide Predicting Machine, or Tide Predictor No. 2, contains 24 components, the complicated tides of the coasts of India requiring a much closer treatment than those considered in the design of the first machine. A third tide predictor, known as No. 3, was designed by Sir Wm. Thomson and constructed about 1881. It is substantially like No. 2, except that it has 16 instead of 20 components, and that, for the sake of greater rigidity, spur instead of bevel gears are employed.

A copy of either No. 2 or No. 3 was made for the French Government about ten years ago, and is used in the preparation of the French tide tables. Another copy was acquired two years ago by the Government of Brazil. All these machines trace a tide curve only, which must be scaled off for obtaining the heights of the high and low waters to be made up into properly arranged tables for the printer.

The Ferrel Tide Predicting Machine.

In 1881, Prof. Wm. Ferrel, of the U. S. Coast and Geodetic Survey, designed a tide predicting machine upon principles differing materially from that of the machines before mentioned. (See Fig. 2.) The contract for its construction was given to Fauth & Co., Instrument Makers, Washington, D. C. It was completed in 1882 and was used for preparing the tide tables of the Coast and Geodetic Survey from 1883 until 1910.

Instead of tracing a curve, it indicates numerically the times and heights of the successive high and low waters by means of pointers moving over dials and scales, from which the results

are copied directly upon the forms for the printer. The space available here does not permit of making clear how the principles underlying its structure are carried out. Suffice it to say that the principal lunar component is set up in the machine as the standard. The other components, moving at speeds equal to the differences between their speed ratios and that of the mean moon, are provided with two cranks fixed at right angles to each other, one set of these cranks summing the cosine series for heights and the other the sine terms of the first derivative of the cosine series for the times of the tides.

By an ingenious device producing mechanically the triangle representing the sums of the cosine and sine terms, an oscillating needle is made to add or subtract the angle by which the pointer representing the mean moon is in error of the real moon. Theoretically considered the machine requires separate settings for the heights and times, though practically, for the simpler tides, as those of the eastern coast of the United States and the western coast of Europe, a single setting is made to suffice.

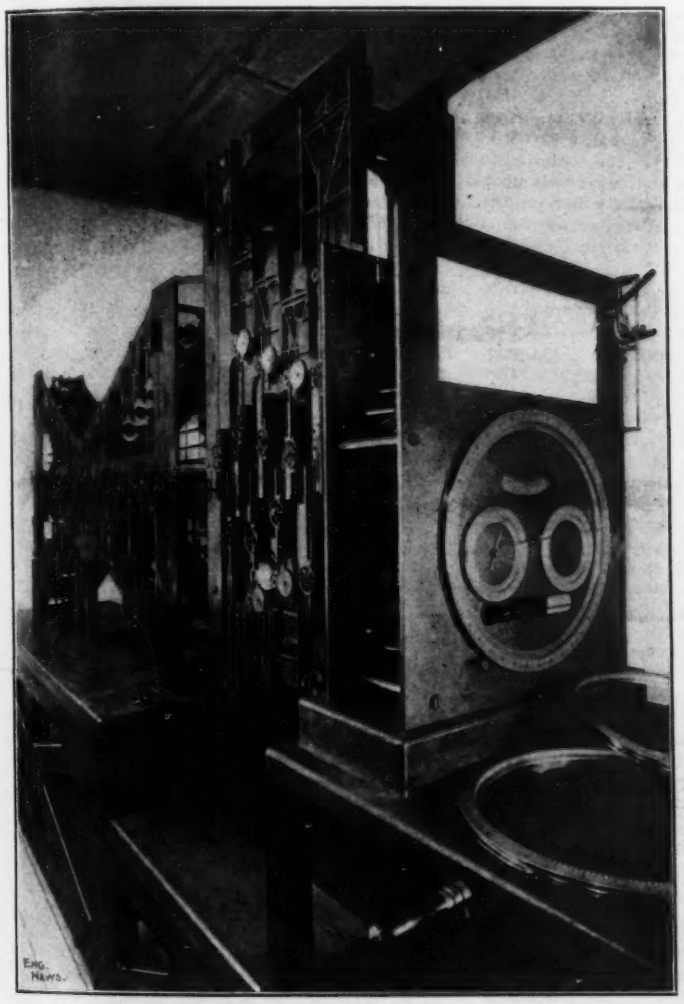


FIG. 3. C. & G. SURVEY TIDE PREDICTING MACHINE NO. 2: HEIGHT SIDE.

As the machine was designed to be set upon a table or desk, its dimensions as a whole (18 ins. × 14 ins. × 24 ins.) necessitated those of its parts, as pitch and diameter of gear wheels, diameters of shafts, etc., to be such as failed to provide sufficient rigidity, when set up with amplitudes for tides of the larger ranges. Also, in the case of the more complicated tides, the triangle representing the sums of the sine and cosine terms frequently becomes so small that the mechanical device fails and requires the operator's attention and assistance in order to obtain accurate results. Twelve years' almost constant use had caused considerable wear. For these reasons it was deemed advisable to replace it by a new machine, which should be most comprehensive, accurate, rapid and durable.

Coast and Geodetic Survey Tide Predicting Machine No. 2.

In the light of the experience gained from the previous machines as regards the theory involved, the problem of designing such a machine had become largely a mechanical one. The writer, who, while in the employ of Fauth & Co., had made under the immediate direction of Prof. Ferrel, the working drawings and constructed with his own hands the Ferrel machine, and had later been called to take charge of the instrument work of the Coast and Geodetic Survey, was entrusted with the planning, designing and constructing of a new machine, which should possess the desired properties. His plans were accepted by the Instrument Board of the Survey in 1895, and the work of construction was begun in 1896. Only such time as could be spared from the regular and the more pressing work of the instrument shop could be utilized, and for about three years a reduction of the force of employees made it necessary to suspend work altogether. So that it was not until February, 1910, that the new machine was completed and could be used for the prediction of tides.

In making the first plans for the machine, the following requirements were held in view: It should, like the Federal machine, indicate the results numerically for direct copying upon the forms for the printer; it should indicate, with only one setting of the components, not only the times of high and low waters, but also the heights at any instant; the height amplitudes should be 1/24 of actual size, or on a scale of ½-in. to 1 ft.; it should produce automatically, for purposes of record in place of the duplicates of the printer's copy, a true tide curve for a length of one year, upon scales of from 1:15 to 1:120, marked off into hour spaces of ½-in. per hour, or 1 ft. per day; it should provide for 37 components.

Before deciding upon the general form of the machine, the writer studied exhaustively the subject of mechanical summation, with the hope of improving upon the chain and pulley; but all the methods suggesting themselves, when considered in detail, led back to that as the simplest method of summing harmonic series.

The fact that the sum of a harmonic series of cosine terms is either a maximum or a minimum when its first derivative becomes zero, was already made use of in the Ferrel machine for finding the time of high and low water, by fitting each component shaft with two cranks, one for the cosine summation and the other for sine summation, at right angles to each other. The same principle was applied in the new machine, as proposed by Dr. R. A. Harris of the Coast and Geodetic Survey. The series

$$H_o + A\cos(at + a) + B\cos(bt + \beta) + C\cos(ct + \gamma) + \ldots\ldots$$

is summed on one side of the machine for the heights (Fig. 3), the free end of the chain being made to indicate by a pointer upon a dial, the height of the tide at any instant in feet and tenths; and at the same time to impart vertical motion, through gearing adjustable to different scales, to a pen tracing the record tide curve. The cranks on the opposite side of the machine (see half-tone on p. 69), at right angles to those summing the cosine series, sum the sine terms in its first derivatives: $Aa \sin(at + a) + Bb \sin(bt + \beta) + Cc \sin(ct + \gamma) + \ldots$. The movement of the chain representing this summation is in view of the operator. When the zero link of the chain comes under a fixed index, the pointers on the day, hour and minute dials show the time of the high or low water indicated by the pointer on the height dial. The amplitude scales of the sine cranks are graduated into units in accordance with the requirements of the derived series, but the amplitude settings of both cosine and sine cranks, while different in actual length have numerically the same number of units.

[Just how the pulleys and chain act may be seen from Fig. 6. Suppose one end of the chain fixed at F, and passed over the pulley A. The disk A is made to rotate and the crank then gives to the yoke A a true linear harmonic motion, raising and lowering the pulley A. Suppose the disk B fixed so as to have no rotation. The free end of the chain P then traces the true harmonic curve C_1, upon a strip of paper passed under it at a uniform rate of speed. Suppose now

Fig. 4. Driving Crank.

that the disk B, rotate with its given amplitude and epoch setting and the disk A be kept motionless. A harmonic curve represented by C_2 will now be traced on the paper. If the two disks A and B be allowed to rotate simultaneously the sum of the two curves C_1 and C_2, represented by C_3 will result. Similarly any number of component harmonic curves may be combined.—Ed.]

Upon the front part of a strong base structure, which also serves as a desk, rests a case housing the gearing for the height and time dials and the curve tracing apparatus. It is composed of two hard rolled brass plates 5/16-in. thick, 19 ins. wide and 24½ ins. high, secured to each other 6 ins. apart. Upon its front is mounted the required height scale of 10, 20 or 40 ft., subdivided to tenths of feet. Within this ring are mounted two dial rings, the one on the left graduated to 24 hours, and that on the right to 60 minutes. Immediately above these is a curved opening exposing part of the day and month dial revolving within the case, the days being pointed out by an index on the plate. Upon the space above these dials is exhibited, for a lateral distance representing 26 hours, the tide curve traced upon a strip of paper 6 ins. high, which issues from a slot on the right side, passes across and enters the case through a slot on the left side of the face. At the right side an adjustable fountain pen is mounted on a carriage

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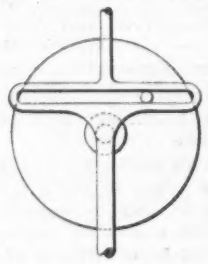

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The First Tide Predicting Machine.

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As the machine was designed to be set upon a table or desk, its dimensions as a whole (18 ins. × 14 ins. × 24 ins.) necessitated those of its parts, as pitch and diameter of gear wheels, diameters of shafts, etc., to be such as failed to provide sufficient rigidity, when set up with amplitudes for tides of the larger ranges. Also, in the case of the more complicated tides, the triangle representing the sums of the sine and cosine terms frequently becomes so small that the mechanical device fails and requires the operator's attention and assistance in order to obtain accurate results. Twelve years' almost constant use had caused considerable wear. For these reasons it was deemed advisable to replace it by a new machine, which should be most comprehensive, accurate, rapid and durable.

Coast and Geodetic Survey Tide Predicting Machine No. 2.

In the light of the experience gained from the previous machines as regards the theory involved, the problem of designing such a machine had become largely a mechanical one. The writer, who, while in the employ of Fauth & Co., had made under the immediate direction of Prof. Ferrel, the working drawings and constructed with his own hands the Ferrel machine, and had later been called to take charge of the instrument work of the Coast and Geodetic Survey, was entrusted with the planning, designing and constructing of a new machine, which should possess the desired properties. His plans were accepted by the Instrument Board of the Survey in 1895, and the work of construction was begun in 1896. Only such time as could be spared from the regular and the more pressing work of the instrument shop could be utilized, and for about three years a reduction of the force of employees made it necessary to suspend work altogether. So that it was not until February, 1910, that the new machine was completed and could be used for the prediction of tides.

In making the first plans for the machine, the following requirements were held in view: It should, like the Federal machine, indicate the results numerically for direct copying upon the forms for the printer; it should indicate, with only one setting of the components, not only the times of high and low waters, but also the heights at any instant; the height amplitudes should be 1/24 of actual size, or on a scale of ½-in. to 1 ft.; it should produce automatically, for purposes of record in place of the duplicates of the printer's copy, a true tide curve for a length of one year, upon scales of from 1:15 to 1:120, marked off into hour spaces of ½-in. per hour, or 1 ft. per day; it should provide for 37 components.

Before deciding upon the general form of the machine, the writer studied exhaustively the subject of mechanical summation, with the hope of improving upon the chain and pulley; but all the methods suggesting themselves, when considered in detail, led back to that as the simplest method of summing harmonic series.

The fact that the sum of a harmonic series of cosine terms has either a maximum or a minimum when its first derivative becomes zero, was already made use of in the Ferrel machine for finding the time of high and low water, by fitting each component shaft with two cranks, one for the cosine summation and the other for sine summation, at right angles to each other. The same principle was applied in the new machine, as proposed by Dr. R. A. Harris of the Coast and Geodetic Survey. The series

$$H_o + A\cos(at + \alpha) + B\cos(bt + \beta) + C\cos(ct + \gamma) + \ldots\ldots$$

is summed on one side of the machine for the heights (Fig. 3), the free end of the chain being made to indicate by a pointer upon a dial, the height of the tide at any instant in feet and tenths; and at the same time to impart vertical motion, through gearing adjustable to different scales, to a pen tracing the record tide curve. The cranks on the opposite side of the machine (see half-tone on p. 69), at right angles to those summing the cosine series, sum the sine terms in its first derivatives: $Aa \sin(at + \alpha) + Bb \sin(bt + \beta) + Cc \sin(ct + \gamma) + \ldots$. The movement of the chain representing this summation is in view of the operator. When the zero link of the chain comes under a fixed index, the pointers on the day, hour and minute dials show the time of the high or low water indicated by the pointer on the height dial. The amplitude scales of the sine cranks are graduated into units in accordance with the requirements of the derived series, but the amplitude settings of both cosine and sine cranks, while different in actual length have numerically the same number of units.

[Just how the pulleys and chain act may be seen from Fig. 6. Suppose one end of the chain fixed at F, and passed over the pulley A. The disk A is made to rotate and the crank then gives to the yoke A a true linear harmonic motion, raising and lowering the pulley A. Suppose the disk B fixed so as to have no rotation. The free end of the chain P then traces the true harmonic curve C_1, upon a strip of paper passed under it at a uniform rate of speed. Suppose now

Fig. 4. Driving Crank.

that the disk B, rotate with its given amplitude and epoch setting and the disk A be kept motionless. A harmonic curve represented by C_2 will now be traced on the paper. If the two disks A and B be allowed to rotate simultaneously the sum of the two curves C_1 and C_2, represented by C_3 will result. Similarly any number of component harmonic curves may be combined.—Ed.]

Upon the front part of a strong base structure, which also serves as a desk, rests a case housing the gearing for the height and time dials and the curve tracing apparatus. It is composed of two hard rolled brass plates 5/16-in. thick, 19 ins. wide and 24½ ins. high, secured to each other 6 ins. apart. Upon its front is mounted the required height scale of 10, 20 or 40 ft., subdivided to tenths of feet. Within this ring are mounted two dial rings, the one on the left graduated to 24 hours, and that on the right to 60 minutes. Immediately above these is a curved opening exposing part of the day and month dial revolving within the case, the days being pointed out by an index on the plate. Upon the space above these dials is exhibited, for a lateral distance representing 26 hours, the tide curve traced upon a strip of paper 6 ins. high, which issues from a slot on the right side, passes across and enters the case through a slot on the left side of the face. At the right side an adjustable fountain pen is mounted on a carriage

with vertical motion for tracing the record curve. Immediately adjacent is mounted another fountain pen, adjustable to a correct fixed position, for tracing the line representing mean sea level. (See Fig. 3.)

Immediately behind the dial case, upon a depression of the base, 18 ins. from the floor, is mounted a frame, made up of two hard rolled brass plates, 11/32 ins. thick, 24 ins. wide and 56¼ ins. high, held 7 ins. apart by ⅝-in. round posts, in which are mounted the shafts of the larger components and their mechanisms. Behind this, on a part of the base 25¾ ins. from the floor, is placed the frame accommodating the remainder of the component shafts and their mechanisms. The thickness of the plates and the space between them are the same as those of the other frame. Its height is 40¼ ins., and the length 56¼ ins.

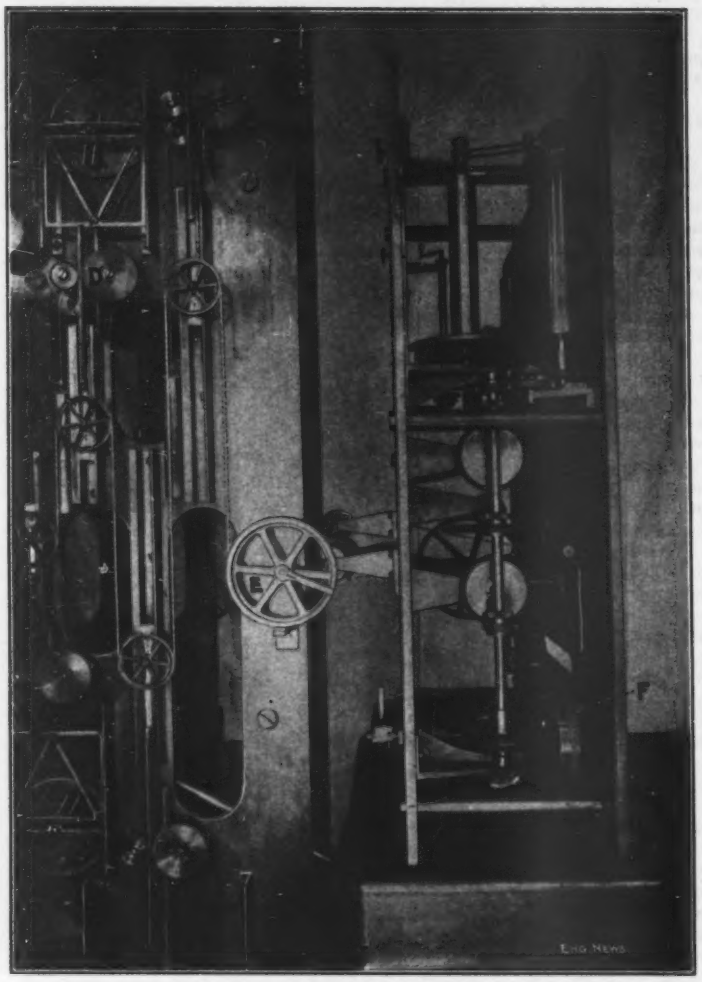


FIG. 5. DIAL CASE: HEIGHT SIDE.

D. Rack and Pinion for Doubling Motion.
E. Weight Chain Wheel.
F. Time Chain Wheel.

A crank at the left side of the desk (Fig. 4) is geared to an inclined shaft which at its upper end connects by conical gears with a vertical driving shaft mounted at the rear of the front section of the frame. (First page view.) By spur gears connection is made with a similar vertical shaft in the front of the rear section of the frame, which in turn is connected by a horizontal shaft and conical gear wheels to a third vertical shaft at the rear end. A fourth vertical shaft (Fig. 5), within the dial case, is driven through conical gears and intermediate shafts by the inclined shaft below the desk. All these vertical shafts revolve once in three turns of the crank. Those in the component frames impart motion, through intermediate shafts and two pairs of conical gears, to the component shafts.

The vertical shaft within the dial case drives, by means of two pairs of conical gears each, the pointers of the 24-hour and 60-minute dials, and, by means of two conical gears and a worm-screw gearing into a worm wheel with 366 teeth, the day and month dial. The ratios of these gears are such that all the vertical shafts make two revolutions when the 24-hour pointer makes one, or indicates one day.

A special device provides for the extra day of leap years. A small pointer under the index pointing out the days, when thrown over to the words "Leap Year," causes the index to remain stationary when the 29th February passes by; but, when thrown over to the words "Common Year," the index jumps over to March 1, when the 28th February has passed. (The plates with the legends had not been mounted when the photographs were taken.)

From the upper end of the vertical shaft within the dial case motion is imparted, by means of spur gears 1:1, through a ratchet stud gear, to the feed cylinder of the curve tracing apparatus. This cylinder has a circumference of 6 ins. and is fitted near its ends with fine needle points. This unwinds and pulls across the front of the face a roll of bond paper .0024-in. thick, 6 ins. high and 380 ft. long, mounted on a friction shaft on the right hand side, and rewinds it upon a receiving roller on the left of the case, by means of a friction sprocket and chain drive. The paper moves at the rate of 12 ins. per revolution of the 24-hour pointer. The ratchet stud gear leaves the paper at rest when the machine is turned backwards. When desired the paper feed can be thrown out of action altogether by the turning of a small button on the ratchet stud gear.

The component shafts are made of steel 5/16 ins. in diameter and run in hard cast iron bushings riveted to the plates. The cranks are of hard cast brass and have perpendicular slots milled through them, for clamping the steel crank pin at any point. The crank pin is fitted smoothly into a hardened steel block which moves freely in the horizontal slot of a light steel frame, 1/16-in. thick. This steel frame is confined in the grooves of two vertical guides and connected by a slender strip of steel to the steel side carrying the chain pulley. The pulleys have a diameter of 2 ins. measured on center of chain.

The chain pulley slide moves in a brass guide piece, one side of which is widened to accommodate the amplitude scale and its numbering. An adjustable index is secured to the pulley slide for reading this scale. Each component crank carries a pointer by means of which the epoch is set off upon a graduated circle mounted against the plate immediately behind the crank.

The slowest five components are driven by one pair of gear wheels and a worm screw and worm wheel; they are provided with short auxiliary shafts and gearing for disengaging and quickly setting the epoch.

Each of the component shafts can be released, set to its proper epoch and firmly secured in place, by screwing down a clamp nut, forcing a dished and split washer or disk against the edge of a recess turned into the gear wheel on the vertical driving shaft. Each of the vertical driving shafts can be clamped to avoid disturbing one setting by another.

The scale of ½-in. to 1 ft. adopted for the height amplitudes required lengths for the cranks which could not be accommodated within the space to which the machine had to be restricted. The largest component, for instance, that representing the mean moon, requires a crank 10 ins. long, if set to its maximum amplitude. To save space two components were provided in place of one, and the motion of each of the two steel frames was doubled by means of a rack fastened to it, which gears into the smaller of two gear wheels with ratio of 1:2. Another rack fastened to the pulley slide is geared into the larger wheel. This allowed of the use of 2½-in. cranks in the halves of the principal lunar component. In the same manner three other components were accommodated, while a number were reduced in size by the use of doubling gears alone. Counterpoise weights are provided for the upper row of double-geared components for balancing the weights of the racks. (See Fig. 5.)

The ratios of the gear wheels conveying motion from the vertical driving shafts to the component shafts are simple arithmetical expressions of the speed ratios given in Thomson's table, obtained by trial factoring. They have been worked out a number of times in connection with the earlier machines built. Quite a number of the speed ratios being expressible in more than one combination of the four wheels,

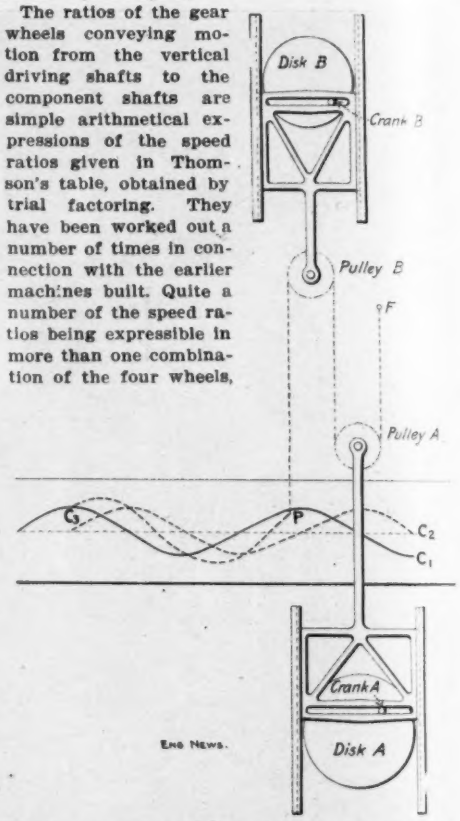


Fig. 6. Method of Mechanically Adding Harmonic Motions.

the writer was able, by recomputing them, to arrange the components as to their location so as to reduce considerably the dimensions of the machine as a whole. The ratios as employed are correct to a small fraction of a degree per year; that is, the epoch settings are correct within one or two tenths of a degree after running the machine through a year as indicated on the dials.

In arranging the location of the components care was taken to place those with the largest amplitudes and highest speeds nearest to the source of power, as far as the dimensions of their parts would permit. The product of the speed into the amplitude was taken as a measure in the selection of their positions.

The left side of the machine, facing the dial case, carries the height or cosine cranks; the right the time or sine cranks. At the rear end on the left side is the fixed end of the height chain, fastened in such manner as to permit of its being let out or taken in by an inch or so for accurate adjustment. The chain is of the chronometer fuse type, of tempered steel, 0.1-in. wide and 0.05 ins. thick, and has 125 links per foot. It passes under and over all the height pulleys of the rear frame; is led across the space between the rear and front frames by means of two stud pulleys, and over and under the height pulleys of the front frame. Leaving the last of

the pulleys it is fastened to a thread grooved wheel 12 ins. in circumference, about which it is wound by means of a counterpoise weight suspended within the frame. (See Fig. 5.) When all the height components are set to zero amplitude, half of the threads of this chain wheel are filled with chain, and an index secured to it coincides with an index fastened to the plate. The total length of the height chain is 27 ft. 7 ins., the load on it due to the counterweight is 6 oz.

The chain wheel is mounted on a shaft which carries a grooved wheel 2 ins. in diameter holding the cord of the counterpoise weight. By means of two spur gears with a ratio of 30 to 100, motion is imparted by this shaft to another secured to the rear of the dial case, which, by a pair of miter gears, moves the pointer of the height scale, clockwise, indicating rising water, when the effect of the components is to take in chain, and counter clockwise, indicating falling water, when chain is let out.

Upon the shaft carrying the miter gears for giving motion to the height pointer is also mounted a set of three-change gears, by means of which a short shaft with a chain wheel 4 ins. in circumference can be moved at ratios of 1:1, 2:3 and 1:2. A chain secured to this wheel passes through the dial case around a pulley, upward and through a clamp in the pen carriage, and over another pulley through the frontplate to a counterpoise weight, thus connecting the curve pen positively with the height chain pulley.

The summation chain on the time side of the machine, from an adjustable fastening in the extreme rear, passes under and over all the time pulleys in the same manner as that of the height chain, until it leaves the last component pulley, whence it is led around a stud pulley secured to the base, forward around another under the desk, up through the desk into the dial case and, having now made a quarter-turn, over another stud pulley across the dial case immediately behind its face, to the time chain wheel which runs in bearings in the plates. A counterpoise weight, rising and falling below the desk is provided as in the case of the height chain wheel for taking in the slack chain. When all the sine or time cranks are set to zero amplitude the time chain wheel is half filled, and a platinum point on the chain, marking its zero, is in contact with a platinum tipped index in the middle of a horizontal opening in the face of the dial case. The length of this chain, measured to the platinum point, is 27 ft. 1 in., the total length being 30 ft. 7½ ins.

The fixed fountain pen provided for tracing the base line is mounted on a shaft carrying the armatures of two pairs of electromagnets. The upper pair of these magnets is in circuit with a battery and a contact spring resting upon a rubber wheel secured upon the shaft carrying the 24-hour pointer. In the edge of this rubber wheel are imbedded 24 platinum strips representing the hours of the day, the 24th hour being marked by a double strip. When rotating, successive contacts are made, which throw the base line pen downward, thus marking off the hour spaces, midnight being indicated by a double mark.

When the platinum point on the time chain comes in contact with the platinum tipped index, another electric circuit is closed, causing the lower pair of magnets to throw the base line pen upward for an instant, thereby marking the time of each high and low water.

In order to relieve the operator of the strain incident to watching for the exact moment when to stop the machine for copying off its face readings of high and low water, a third electric circuit is provided, by means of which the machine is stopped automatically at the instant when the zero point of the time chain marks a high or low water. This is accomplished by an electro-magnet under the desk, which, when the circuit is closed by a contact device on the rear end of the shaft carrying the time chain wheel, throws down a ratchet pawl upon a fine-toothed ratchet wheel secured to the driving crank shaft. The circuit is led through the arm of the driving crank, and can be broken by a slight, momentary inward pressure against the crank handle, thus releasing the ratchet wheel and allowing the machine to be turned on to next stop. Cut-out switches for this and other circuits are also provided.

Properties considered.	Structural steel grade.		Hard grade.*		
	Plain bars.	Deformed bars.	Plain bars.	Deformed bars.	Cold-twisted bars.
Phosphorus, max.					
Bessemer	0.10%	0.10%	0.10%	0.10%	0.10%
Open-hearth	0.05%	0.05%	0.05%	0.05%	0.05%
Ult. tensile strength, lbs. per sq. in.	55,000-70,000	55,000-70,000	80,000 min.	80,000 min.	Recorded only
Yield point, min., lbs. per sq. in.	33,000	33,000	50,000	50,000	55,000
Elongation, min. per cent. in 8 ins.	1,400,000 / tens. str.	1,250,000 / tens. str.	1,200,000 / tens. str.	1,000,000 / tens. str.	5%
Cold bend without fracture:					
Bars under ¾-in. in diameter or thickness	180° d. = 1t.	180° d. = 1t.	180° d. = 3t.	180° d. = 4t.	180° d. = 2t.
Bars ¾-in. in diameter or thickness and over	180° d. = 1t.	180° d. = 2t.	180° d. = 3t.	180° d. = 4t.	180° d. = 3t.

*The hard grade will be used only when specified.

With the amplitude and epoch table, taken from the files, in hand, the operator prepares the machine for predicting the tides for a station The three vertical driving shafts are clamped. Each component is released by loosening with a pin wrench the clamp nut of the gear wheel on the driving shaft; using this gear as a milled head, the crank is set in a vertical position pointing towards its chain pulley; with a milled head wrench the crank pin is released, moved until the index on the pulley slide indicates upon the amplitude scale the amplitude setting for the component, and re-clamped; the crank on the opposite side of the machine is then set vertical and its amplitude set in like manner. The component shaft is then turned until the pointer on the crank indicates upon the degree dial the degrees and tenths of the epoch, after which the clamp nut on the gear wheel is tightened. This is done for all the components entering into the tide to be predicted. All those not required are set to zero amplitude, which leaves their pulleys at rest and, consequently, out of action.

The vertical driving shafts are then unclamped and the day, hour and minute dials set to Jan. 1, 0 hour, 0 minute. After this the machine is turned until the index on the height chain wheel indicates the sum of the height components to be zero and therefore represents mean sea level; in which position the pointer on the height dial is set to the height representing the plane, usually mean low water, to which the tides in the tide tables are referred. The machine is then turned back to the position indicating Jan. 1, 0 hour, 0 minute.

A new roll of paper having been mounted, the pens filled and the electric switches thrown in, the machine is ready for predicting. The operator, sitting at the desk, has before him the printed blank form; with his left hand he turns the crank until it stops; he copies from the dials the hours, minutes, feet and tenths indicated by their respective pointers, the day of the week and the month being already given on the blank in print. He then pushes the crank handle inward and turns the crank until it is again arrested by the stopping device, and so on.

The time required by one man for setting the machine varies, according to the number of components used, from about 2½ to 4 hours; that for the prediction of one year's tides ready for the printer from about 8 to 15 hours.

The degree of accuracy of the predictions was thoroughly tested by setting the machine for two stations with tides of a nature most likely to reveal faults of design or construction. The stations selected were Aden, Arabia and Hong Kong, China. The number of the components used in the first was 35, and the latter 33. The machine was run through nearly a year before 24 hourly heights were read to hundredths of a foot. The comparison of these heights with those obtained by careful computation showed a maximum difference of 0.02 ft. in the case of the Aden tide, and 0.06 ft. in that of Hong Kong.

Proposed Standard Specifications for Steel Bars for Concrete Reinforcement.*

MANUFACTURE.

1. Steel may be made by either the open-hearth or Bessemer process. Bars shall be rolled from billets.

*Reported to the American Society for Testing Materials at its general meeting at Atlantic City, N. J., June 28, 1911, by the society's Committee A-1, on Standard Specifications for Steel, and approved by the meeting for submission to letter ballot.

CHEMICAL AND PHYSICAL PROPERTIES.

2. The chemical and physical properties shall conform to the following limits:

CHEMICAL DETERMINATIONS.

3. In order to determine if the material conforms to the chemical limitations prescribed in Paragraph 2 herein, analysis shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt or blow of steel, and a correct copy of such analysis shall be furnished to the engineer or his inspector.

4. Chemical determinations of the percentage of phosphorus shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel and a correct copy of such analysis shall be furnished to the engineer or his inspector. Check analyses may be made from finished material by the purchaser, in which case an excess of 25% above the required limits will be allowed.

YIELD POINT.

5. For the purposes of these specifications, the yield point shall be determined by careful observation of the drop of the beam of the testing machine, or by other equally accurate method.

FORM OF SPECIMENS.

6. (a) Tensile and bending test specimens may be cut from the bars as rolled, but tensile and bending test specimens of deformed bars may be planed or turned for a length of at least 9 ins. if deemed necessary by the manufacturer in order to obtain uniform cross-section.

(b) Tensile and bending test specimens of cold-twisted bars shall be cut from the bars after twisting, and shall be tested in full size without further treatment, unless otherwise specified as in (c), in which case the conditions therein stipulated shall govern.

(c) If it is desired that the testing and acceptance for cold-twisted bars be made upon the hot-rolled bars before being twisted, the hot-rolled bars shall meet the requirements of the structural steel grade for plain bars shown in this specification.

NUMBER OF TESTS.

7. At least one tensile and one bending test shall be made from each melt of open-hearth steel rolled, and from each blow or lot of ten tons of Bessemer steel rolled. In case bars differing ⅜-in. and more in diameter or thickness are rolled from one melt or blow, a test shall be made from the thickest and thinnest material rolled. Should either of these test specimens develop flaws, or should the tensile test specimen break outside of the middle third of its gaged length, it may be discarded and another test specimen substituted therefor. In case a tensile test specimen does not meet the specifications, an additional test may be made.

(d) The bending test may be made by pressure or by light blows.

MODIFICATIONS IN ELONGATION FOR THIN AND THICK MATERIAL.

8. For bars less than 7/16-in. and more than ⅝-in. nominal diameter or thickness, the following modifications shall be made in the requirements for elongation:

(e) For each increase of ⅛-in. in diameter or thickness above ⅝-in., a deduction of 1 shall be made from the specified percentage of elongation.

(f) For each decrease of 1/16-in. in diameter or thickness below 7/16-in., a deduction of 1 shall be made from the specified percentage of elongation.

(g) The above modifications in elongation shall not apply to cold-twisted bars.

NUMBER OF TWISTS.

9. Cold-twisted bars shall be twisted cold with one complete twist in a length equal to not more than twelve (12) times the thickness of the bar.

FINISH.

10. Material shall be free from injurious seams, flaws, or cracks, and have a workmanlike finish.

VARIATION IN WEIGHT.

11. Bars for reinforcement are subject to rejection if the actual weight of any lot varies more than 5% over or under the theoretical weight of that lot.

INSPECTION.

12. When an inspector is furnished by the purchaser to inspect material at the mills, he shall have full access, at all times, to all parts of mills where material to be inspected by him is being manufactured.

Road Tests of Oil-Cement Concrete, U. S. Office of Public Roads.

Several times in the past we have referred to experiments now being undertaken by the U. S. Office of Public Roads (Mr. Logan W. Page, M. Am. Soc. C. E., Director) into the availability of an oil admixture to a cement concrete for use as a roadway surfacing. The Bureau has recently issued a bulletin* which, among other things, describes the present status of some of these tests. These tests were carried on in the District of Columbia, New York City and Ridgewood, N. J. The account of the experiments is as follows:

District of Columbia.

During the month of June, 1910, the Office of Public Roads, in cooperation with the District of Columbia, conducted a series of experiments on Meridian Place to determine the value of oil-cement concrete as a road surface. Certain laboratory investigations had indicated that a mixture of Portland cement concrete with residual petroleums might possibly be suitable for this purpose, and the following experiments were therefore made for the purpose of trying such mixtures in a thoroughly practical manner.

The part of the street selected for this work runs from Center St. east toward Fourteenth St., a distance of 356.1 ft. It is 19.5 ft. between gutters. The soil forming the subgrade is a coarse gravelly red clay, which after a rain becomes sticky on the surface, but remains firm below. The grade here is light and slopes toward the west. The north curb is 6 in. lower than the south curb, because of the fact that the District constructs its cross streets on the same grade as the main streets running north and south. Meridian Place is subjected to light traffic consisting of delivery wagons and pleasure vehicles. When the office of Public Roads assumed supervision of the work, all grading had been completed and the curbs and gutters were in place. The cost data given in this report, therefore, include the cost only from this point on.

The foundation of the road was constructed in two courses, the first of which consisted of from ½-in. to 1½-in. broken stone placed to a depth of 5 ins. loose upon the prepared subgrade. After this course had been rolled until firm with a 12-ton 3-wheel roller, screenings ranging from ¼-in. to dust were applied, and the surface finished as in ordinary macadam road work. This method of construction was followed in the preparation of the foundation for all of the experiments.

Common labor for this work cost $1.50 per 8-hr. day; foreman, $4; double teams, $4; a 5-ton tandem roller, $8; the 3-wheel roller, $12; and a "bug" concrete mixer, $4 per day. Stone and sand cost $2.50 per cu. yd., delivered on the work. The oils and cement were donated, but their cost, including freight, is given in the cost data. The following experiments are given in the order in which they were conducted.

EXPERIMENT NO. 1, SECTION NO. 7.—FLUID RESIDUAL PETROLEUM.—Section No. 7 is 65.8 ft. in length. A stiff mortar of 1 part cement to 2 parts sand was first prepared by hand on a mixing board, and oil to the amount of 10% by weight of the cement was then mixed with the mortar. The resulting mixture was laid over the prepared foundation to a depth of 1¼ ins. and immediately covered with broken stone, similar to that used in the foundation, to a depth of 2½ ins. One side of the street was thus laid at a time and, when about 20 lin. ft. had been covered, an attempt was made to force the stone down into the mortar by rolling it with the 5-ton tandem roller. After the entire section had been rolled, it was found that the mortar had not been worked up into the voids of the stone course sufficiently. The road was, therefore, sprinkled and again rolled in the hope that a homogeneous mixture might thus be made. As this did not give the desired results, it was decided to grout the surface. A thin mortar of the same composition as that previously described was therefore prepared, poured over the surface, and "broomed" in. This last process roughened up the surface somewhat, but otherwise the section was finished off in good condition by the application of a light coat of stone screenings running from ¼-in. to dust. The characteristics of the oil used in this experiment are shown in Table I.

TABLE I.—ANALYSIS OF PETROLEUM RESIDUAL OIL USED IN EXPERIMENT NO. 1—OIL-CEMENT CONCRETE.

Specific gravity 25°/25° C.	0.936
Viscosity at 50° C., Engler, 100 c. c., specific	44.1
Per cent. of loss at 163° C., 5 hours* (20 grams)	1.26
Per cent. of bitumen insoluble in 86° B. paraffin naphtha	1.90
Per cent. of fixed carbon	3.40
Per cent. of bitumen soluble in CS_2, air temperature (total bitumen)	99.92
Organic matter insoluble	.06
Inorganic matter	.02
	100.00

*Fluid, very slightly sticky; too soft for consistency test.

EXPERIMENT NO. 2, SECTION NO. 6—FLUID RESIDUAL PETROLEUM.—This section is 24.3 ft. in length. The concrete aggregate for this experiment was composed of a 1½:2:4 mixture of cement, sand and broken stone. The same oil as described in experiment No. 1 was added to the extent of 19% by weight of the cement, after a mortar of the cement and sand had been prepared and before the broken stone was mixed in. The stone in this and the following experiments consisted of crushed trap ranging from 1½ ins. to ¼ in. in diameter.

The mixture was laid to a depth of 2½ in. over the prepared foundation and tamped until the mortar flushed to the surface and filled all voids. The resulting surface was not troweled, but was purposely left somewhat rough. While rolling an adjoining section the next day, the roller was run over this surface, causing slight cracks to develop in places. When last inspected, on January 31, however, no evidence of these cracks could be found.

EXPERIMENT NO. 3, SECTION NO. 5—FLUID RESIDUAL PETROLEUM.—Section No. 5 is 45 ft. in length. In this and the following experiments the concrete was first prepared in a "bug" mixer. The sand or stone screenings, or both, as the case might be, were first placed in the mixer and the mixer was then driven to the stone pile, so that the cement and fine aggregate were mixed dry. Here the proper proportions of broken stone, water and oil were added and, after the machine had been driven about 500 ft., the concrete was dumped upon a board. As it was not thoroughly mixed, it was then turned twice by hand before shoveling it upon the road. After it had been placed in position, it was raked with the back of steel rakes to the desired grade and crown.

In this experiment the same oil as described in experiment No. 1 was used to the extent of 10% by weight of the cement, and an attempt was made to use stone screenings in place of sand. The first batch was composed of cement, stone screenings and broken trap rock, in the proportions 1½:2:4. As the voids of this mixture were not well filled, the proportions were changed to 1½:3:4 for the remainder of this section. Tamping failed to bring the mortar uniformly to the surface, so the section was rolled with this object in view. As this did not produce the desired result, a cement grout similar to that used in experiment No. 1 was poured over the first 20 ft. of this section adjoining section 6 and "broomed" in. The remaining 25 ft. of the section were thoroughly tamped and troweled off with the back of a shovel.

EXPERIMENT NO. 4, SECTION NO. 4—FLUID RESIDUAL PETROLEUM.—Section No. 4 is 37 ft. in length. As the screenings used in experiment No. 3 did not produce as dense an aggregate as desirable, it was thought well to replace a part of them with sand. The proportion of 1½:1:2:4: of cement, sand, screenings and broken stone was then decided upon for this experiment. This aggregate was also used in the three succeeding experiments. The same oil as described in experiment No. 1 was used in this experiment to the extent of 15% by weight of the cement. The concrete was laid and tamped in the manner previously described and finished off with the back of a shovel.

EXPERIMENT NO. 5, SECTION NO. 3—CUT-BACK PETROLEUM RESIDUE.—Section No. 3 is 68 ft. in length. This experiment was identical in every respect with experiment No. 4, except that a different oil product was used to the extent of 15% by weight of the cement. The properties of this oil are given in Table II.

TABLE II.—ANALYSIS OF CUT-BACK PETROLEUM RESIDUE* USED IN EXPERIMENT NO. 5—OIL-CEMENT CONCRETE.

Specific gravity 25°/25° C.	0.962
Flash point C., open-cup method	35°
Burning point °C., open-cup method	170°
Per cent. of loss at 163° C., 5 hrs. (20 grams)	13.23
Penetration of residue† (N. 2 N, 5 seconds, 100 grams, 25° C.)	116°
Per cent. of fixed carbon	8.90
Per cent. of bitumen soluble in CS_2, air temperature (total bitumen)	99.85
Organic matter insoluble	.12
Inorganic matter	.03
	100.00

*Viscous, fluid, sticky; too soft for penetration determination.
†Semi-solid, sticky.

After laying, no difference between this section and section No. 4 could be noticed, except that the surface of the latter was slightly lighter in color.

EXPERIMENT NO. 6, SECTION NO. 2—CUT-BACK PETROLEUM RESIDUE.—Section No. 2 is 72.4 ft. in length. This experiment is identical with experiment No. 5, with the exception that the cut-back oil was used to the extent of 10% by weight of the cement instead of 15%.

EXPERIMENT NO. 7, SECTION NO. 1—PLAIN CEMENT CONCRETE.—Section No. 1 is 39.4 ft. in length. In this experiment the cement concrete was prepared and laid in exactly the same manner as sections Nos. 3, 4, 5 and 6, except that no oil was used in the mixture. This was done for the purpose of comparing ordinary Portland cement concrete with the oil cement concretes.

SUMMARY.—In the work described it was found that the concrete could be handled best when made sufficiently wet for the mortar to flush to the surface upon tamping, but not so wet that it would not hold its shape after being tamped. The best surface finish was obtained by troweling the wet concrete with the back of a flat No. 2 shovel until smooth and uniform.

All of the sections were closed to traffic for at least seven days after being laid and they were sprinkled with water daily during this time. A thin layer of sand was spread over part of the surface and a thin layer of stone screenings ranging from ¼ in. to dust was spread over the remainder.

When last inspected, on January 31, all of these sections were in excellent condition, although the street was covered with a light coat of mud brought in from other roads. No important difference between the sections could be seen at that time and a considerable period of time will probably be required to determine what practical differences, if any, do exist. The materials and cost data for these experiments are given in Table III.

New York City.

The experiments at New York City were conducted by the Office of Public Roads during the months of May and June, in cooperation with the Bureau of Engineering and Construction of the Borough of Richmond, New York City, for the purpose of ascertaining the value of oil cement concrete as a road material.

The road selected was that part of Innis St. at Elm Park Station, Staten Island, running east from Morning Star Road to John St. This street is subjected to medium traffic, consisting of drays, delivery wagons and automobiles. The oils for these experiments were donated by two oil companies, and the cement was furnished by four manufacturers through the Association of American Portland Cement Manufacturers. The Borough of Richmond, New York City, furnished labor, sand and stone, while the Office of Public Roads paid the freight on both the oil and cement, and furnished supervision of the work.

The foundation for the wearing course of oil cement concrete was prepared by first picking and leveling the rough places of the old macadam surface. The old cobblestones were removed from the gutters and, after the curbing had been cut and reset in concrete, the gutters were relaid with oil-cement concrete, leveled and tamped solid. The old material was allowed to conform to the original surface, and no attempt was made to

*"Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910." Circular No. 94, Office of Public Roads, U. S. Department of Agriculture.

TABLE III.—MATERIALS AND COST DATA OF EXPERIMENTS WITH OIL-CEMENT CONCRETE AT WASHINGTON, D. C.

Experiment No.	Section No.	Description. Oil.	Length of section (ft.)	Area of section (sq. yds.)	Quantity of material. Stone (cu. yds. per sq. yd.)	Screenings (cu. yds. per sq. yd.)	Sand (cu. yds. per sq. yd.)	Cement (cu. yds. per sq. yd.)	Oil (gal. per sq. yd.)	Cost data (cts. per sq. yd.) Stone at mixer.	Screenings at mixer.	Sand at mixer.	Cement at mixer.	Oil at mixer.	Mixing and laying concrete.	Foundation and miscellaneous.	Total cost. Cents (per sq. yd.)	Entire section.
1	7	Fluid residual petroleum	65.8	142.6	0.063	....	0.027	0.015	0.534	15.75	...	6.75	14.18	4.01	24.20	52.52	117.41	$167.43
2	6	" " "	24.3	52.6	.047	.....	.024	.018	.640	11.75	...	6.00	17.01	4.80	23.05	52.52	115.13	60.56
3	5	" " "	45.0	97.5	.047	0.036	....	.018	.640	11.75	9.00	...	17.01	4.80	23.05	52.52	118.13	115.18
4	4	" " "	37.0	80.2	.047	.024	.012	.018	.960	11 75	6.00	3.00	17.01	7.20	23.05	52.52	120.53	96.67
5	3	Cut-back petroleum residue	68.0	147.3	.047	.024	.012	.018	.937	11.75	6.00	3.00	17.01	12.18	23.05	52.52	125.51	184.88
6	2	" " "	72.4	156.9	.047	.024	.012	.018	.625	11.75	6.00	3.00	17.01	8.13	23.05	52.52	121.46	190.57
7	1	None	39.4	85.4	.047	.024	.012	.018	....	11.75	6.00	3.00	17.01	...	23.05	52.52	113.33	96.78

TABLE VI.—MATERIALS AND COST DATA OF EXPERIMENTS WITH OIL-CEMENT CONCRETE AT NEW YORK, N. Y.

Experiment No.	Section No.	Description: Oil.	Description: Length of section (ft.)	Description: Area of section (sq. yds.)	Quantity of material: Stone (cu. yds. per sq. yd.)	Quantity of material: Sand (cu. yds. per sq. yd.)	Quantity of material: Cement (cu. yds. per sq. yd.)	Quantity of material: Oil (gal. per sq. yd.)	Cost data (cents per square yard): Stone at mixer.	Sand at mixer.	Cement at mixer.	Oil at mixer.	Mixing and laying concrete.	Preparing foundation and miscellaneous.	Total cost.: Cents (per sq. yd.)	Entire section.
1	1	Fluid residual petroleum.....	163	380	0.123	0.062	0.031	1.61	18.45	7.13	27.62	12.07	21.78	2.28	89.33	$518.11
2	2	Fluid residual petroleum.....	77	274	.123	.062	.031	1.07	18.45	7.13	27.62	8.02	21.78	2.28	85.28	233.67
3	3	Cut-back petroleum residuum....	100.5	357	.123	.062	.031	1.88	18.45	7.13	27.62	24.44	21.78	2.28	101.70	363.07
4	4	Cut-back petroleum residuum...	103.5	368	.123	.062	.031	1.88	18.45	7.13	27.62	24.44	21.78	2.28	101.70	374.26

obtain a uniform crown in the foundation. The concrete surface was laid upon the foundation as nearly as possible 4 ins. deep, but owing to unevenness in the foundation and to the fact that the concrete was placed somewhat deeper in the gutters, it probably averaged about 4½ in. in thickness over the entire roadway, which was 32 ft. wide between gutters.

A mixer of the old Smith type, driven by a small steam engine, was used in mixing the concrete. The desired mixture was obtained by placing the sand and cement in the machine and adding enough water to form a thin mortar. A bucket of oil was then added alternately with a barrow of stone, until sufficient oil for the batch had been consumed. The remainder of the stone was then added. As the mixer did not satisfactorily mix this last addition of stone with the mortar, a barrow of sand, cement, and oil matrix was taken from the front part of the machine and dumped into the batch again, and the mixing process was then continued. When thoroughly mixed, the concrete was dumped on a board, shoveled into barrows, and wheeled to the road. It was found that, as far as the mixture was concerned, it made no difference in what manner the material entered the machine, and the foregoing method was adopted as the quickest way of mixing a batch.

Each batch consisted of 1 bbl. of cement, 8 cu. ft. of sand, 16 cu. ft. of crushed stone ranging from 1½ ins. to ¾-in. in diameter, together with the proper amount of oil. The concrete was tried both wet and comparatively dry. It was found that a dry mixture was difficult to tamp in such a way as to flush the voids full of mortar. On the other hand, if very wet, it would not hold its shape and, upon drying out, the formation of hair cracks could be noticed. The best results were obtained by adding as much water as the concrete could contain without losing its shape when placed upon the road. The road was closed to traffic for seven days after completion.

For this work common labor cost $1.85 per 9-hr. day; superintendent-foreman, $6; double teams, $4 per day; and the concrete mixer $35 per week. Sand cost $1.15 per cu. yd. delivered at the mixer, and broken stone $1.50 per cu. yd. Although the cement was donated, a cost of $1.32 per bbl. delivered at the mixer is included in the cost data.

EXPERIMENT NO. 1, SECTION NO. 1.—FLUID RESIDUAL PETROLEUM.—Section No. 1 begins at Morning Star Road station 0 and runs east for a distance of 163 ft. In this experiment a fluid residual petroleum, similar to that employed in the experiments at Washington, D. C., was used to the extent of 15% by weight of the cement. The mixture was spread with the back of a steel rake and tamped until the mortar flushed to the surface. The surface was not troweled, but was purposely left rather rough. Each morning the work of the preceding day was covered with about ½-in. of loose sand and was wetted down in order to keep the concrete moist.

The properties of the oil used in this experiment are given in Table IV.

TABLE IV.—ANALYSIS OF PETROLEUM RESIDUAL OIL USED IN EXPERIMENT NO. 1.

Specific gravity 25°/25° C.	0.936
Viscosity at 50° C., Engler, 100 c. c., specific	45.1
Per cent. of loss at 163° C., 5 hours* (20 grams).	.87
Per cent. of bitumen insoluble in 86° B. paraffin naphtha	1.99
Per cent. of fixed carbon	2.85
Per cent. of bitumen soluble in CS_2, air temperature (total bitumen)	99.90
Organic matter insoluble	.08
Inorganic matter	.02
	100.00

*Fluid, very slightly sticky; too soft for consistency test.

EXPERIMENT NO. 2, SECTION NO. 2.—FLUID RESIDUAL PETROLEUM.—Section No. 2 extends from station 1 + 63 to station 2 + 40, a distance of 77 ft. This experiment was identical with experiment No. 1, except that another brand of Portland cement was used and that the fluid residual petroleum was added to the extent of 10% by weight of the cement. The only difference noted between this section and section No. 1 was that the concrete seemed to set somewhat faster in the former.

EXPERIMENT NO. 3, SECTION NO. 3.—CUT-BACK PETROLEUM RESIDUE.—Section No. 3 extends east from station 2 + 40 to station 3 + 40.5, a distance of 100.5 ft. In this experiment still another brand of Portland cement was used and a cut-back petroleum residuum was added to the extent of 18¾% by weight of the cement. The first 40 ft. of this section were laid in exactly the same manner as previously described, but the remainder did not receive the sand covering. For the last 20 ft. the concrete was made very wet, lightly tamped, troweled with the back of a shovel, and floated with a straight edge from crown to curb. After a few days a number of hair cracks were noticed in the last 20 ft. The concrete "set up" slowly as compared with the two preceding sections.

The properties of the oil used in this experiment are shown in Table V.

TABLE V.—ANALYSIS OF CUT-BACK PETROLEUM RESIDUE* USED IN EXPERIMENT NO. 5.

Specific gravity 25°/25° C.	0.957
Flash point, °C., open-cup method.	34°
Burning point, °C., open-cup method.	149°
Per cent. of loss at 163° C., 5 hours (20 grams).	15.23
Penetration of residue† (No. 2 N, 5 seconds 100 grams, 25° C.).	111°
Per cent. of bitumen insoluble in 86° B. paraffin naphtha	17.44
Per cent. of fixed carbon	8.20
Per cent. of bitumen soluble in CS_2, air temperature (total bitumen)	99.84
Organic matter insoluble	.09
Inorganic matter	.07
	100.00

*Viscous, fluid, sticky; too soft for penetration determination.
†Semisolid, sticky.

EXPERIMENT NO. 4, SECTION NO. 4.—CUT-BACK PETROLEUM RESIDUE.—Section No. 4 extends from station 3 + 40.5 to station 4 + 44, a distance of 103.5 ft. In this experiment a fourth brand of Portland cement was used with the cut-back oil to the extent of 18¾% by weight. The work was quite similar to that described in experiment No. 3. Where the mixture was made wet and finished as in the latter part of section No. 3, cracks developed as before. One of these cracks extended across the entire width of the road at station 3 + 55. When this was noticed, the mixture for the last 15 ft. of this section was made less wet and tamped hard before troweling it. Even under these conditions two short cracks about 3 ft. in length developed. Only the first 10 ft. of this section were covered with sand.

SUMMARY.—When last inspected, on Jan. 21, the oil-cement-concrete work at New York did not appear as satisfactory as that done at Washington. The division line between each day's work was plainly apparent, and the entire surface was rather rough and uneven. Inspection was made shortly after a rain and the road appeared in somewhat better condition than when previously inspected during dry weather in October. Sections Nos. 1 and 2 were in better condition than the other two. On section No. 1 a crack, evidently due to a poor joint between two days' work, was noticed extending across the road at station 1 + 20. From station 1 + 48 to station 1 + 52 a number of cup-shaped depressions were noted, although the concrete at these places appeared sound. At station 1 + 52 another crack had developed across the road, but from this point on for a distance of 60 ft. the surface was in excellent condition.

At station 1 + 63 no change in the surface was noted where section No. 2 begins. At station 2 + 18 a crack had formed across the road, but had been filled with dirt and sand so that it was hardly noticeable. At station 2 + 30 the road had been cut transversely for the purpose of laying a pipe, and the trench thus made had been filled merely with the loose material which had been taken out. From this cut a longitudinal crack was noticed extending to station 2 + 40.

On section No. 3 the surface from station 3 + 03 to station 3 + 20 was rather crumbly and could be dug into with a knife to some extent. From station 3 + 20 to station 3 + 40 the concrete was very crumbly, and in fact was scarcely better than ordinary macadam. The stone fragments of the concrete at this point could be readily removed with a pocketknife. This was the worst section of the four.

On section No. 4 three transverse cracks filled with dirt were noticed between stations 3 + 40.5 and 3 + 90. Between these stations the concrete was found to be rather crumbly. From station 3 + 90 onward this section was in better condition, but, while the concrete could scarcely be called crumbly, it could be readily scratched with a knife.

The materials and cost data for these experiments are given in Table VI.

Ridgewood, N. J.

During the months of April and May two experiments with oil-cement concrete in the construction of bridge-floor surfaces were conducted at Ridgewood, N. J., in cooperation with the county highway engineer of Bergen County. These were the first practical experiments with oil-cement concrete made by the office, and were quite similar to those conducted at New York and Washington, D. C., which have already been described in this circular.

In both of these experiments the old wooden bridge floors were replaced with Portland cement concrete laid on iron sheathing and reinforced with "chicken wire." The concrete was laid 6½ ins. thick at the center and tapered to 4½ ins. at the sides, giving an average thickness of 5½ ins. Only the upper layer of from 1½ to 2 ins. of this concrete contained oil.

For this work common labor cost $2.25 per 9-hr. day, and foreman $6 per day. Cement cost 37 cts. per bag, sand 80 cts. per cu. yd., and crushed stone $2.50 per cu. yd., delivered on the work.

EXPERIMENT NO. 1.—FLUID RESIDUAL PETROLEUM.—The bridge on which this experiment was tried is on Paramus Road, crossing Saddle River. It is 37 ft. in length and 19 ft. in width, with a floor surface of 75 sq. yds.

The oil-cement concrete surface was placed continuously with the rest of the concrete in the following manner: After a few batches of the ordinary concrete had been laid and tamped, and while it was still wet, a batch of the oil-cement-concrete was prepared and placed upon the surface to a depth of from 1½ to 2 ins. It was then tamped until the mortar flushed to the surface. By this means the two layers set together in a single course.

The oil-cement concrete was mixed by hand upon a mixing board and shoveled into place. It was composed of Portland cement, bank sand, and crushed trap rock, ranging from ¾-in. to ¼-in. in diameter in the proportion of 1:2:4. The sand and cement were first mixed into a stiff mortar, to which was added a fluid residual petroleum to the extent of 15% by weight of the cement. The stone was next added and mixed in. After the concrete had been placed and tamped, one-half of the surface was covered with a thin coating of sand and one-half with stone screenings. The bridge was closed to traffic for ten days and during that time the surface was kept damp by sprinkling it each day with water. After the concrete had set, it was given a light surface treatment of the same oil at the rate of ⅛-gal. per sq. yd. and sufficient sand was applied to take up any excess of oil.

The properties of the oil used in this experiment are given in Table VII.

TABLE VII.—ANALYSIS OF PETROLEUM RESIDUAL OIL USED IN EXPERIMENT NO. 1.

Specific gravity 25°/25° C.	0.937
Viscosity at 50° C., Engler, 100 c. c., specific.	41.1
Per cent of loss at 163° C., 5 hours* (20 grams).	1.10
Per cent. of bitumen insoluble in 86° B. paraffin naphtha	2.16
Per cent. of fixed carbon	3.40
Per cent. of bitumen soluble in CS_2, air temperature (total bitumen)	99.94
Organic matter insoluble	.03
Inorganic matter	.03
	100.00

*Fluid, very slightly sticky; too soft for consistency test.

EXPERIMENT NO. 2.—CUT-BACK PETROLEUM RESIDUE.—The bridge on which this experiment was tried is on Harrison Ave. crossing Hohokus River. It is 25 ft. in length and 37 ft. in width, with a floor surface of 103 sq. yds.

This experiment was practically identical with experiment No. 1, with the exception that in place of the fluid residual petroleum a cut-back petroleum residue was used to the extent of 18% by weight of the cement.

TABLE IX.—MATERIALS AND COST DATA OF EXPERIMENTS WITH OIL-CEMENT CONCRETE WEARING SURFACE AT RIDGEWOOD, N. J.

Experiment No.	Description: Oil.	Length of section (ft.).	Area of section (sq. yds.).	Quantity of material: Stone (cu. yds. per sq. yd.).	Sand (cu. yds. per sq. yd.).	Cement (cu. yds. per sq. yd.).	Oil in concrete (gals. per sq. yd.).	Oil in surface treatment (gals. per sq. yd.).	Screenings (cu. yds. per sq. yd.).	Cost data (cents per square yard): Stone on work.	Sand on work.	Cement on work.	Oil in concrete on work.	Oil in surface treatment on work.	Screenings on work	Labor.	Total: Cents (per sq. yd.)	[illegible]
1	Fluid residual petroleum	37	78	0.042	0.021	0.010	0.500	0.141	0.006	10.50	1.68	9.99	3.75	1.6	0.99	18.11	46.08	45.94
2	Cut-back petroleum residue	37	103	.034	.017	.008	.544	....	....	8.50	1.36	7.99	7.07	....	....	16.55	41.47	42.71

The properties of this product are shown in Table VIII.

TABLE VIII.—ANALYSIS OF CUT-BACK PETROLEUM RESIDUE* USED IN EXPERIMENT NO. 2.

Specific gravity at 25°/25° C.	0.962
Per cent. of loss at 163° C., 5 hours (20 grams).	13.38
Penetration of residue† (No. 2 N, 5 seconds, 100 grams, 25° C.)	111°
Per cent. of bitumen insoluble in 86° B. paraffin naphtha	18.05
Per cent. of fixed carbon	8.55
Per cent. of bitumen soluble in CS_2, air temperature (total bitumen)	99.85
Organic matter insoluble	.12
Inorganic matter	.03
	100.00

*Viscous, fluid, sticky; too soft for penetration determination.
†Semisolid, sticky.

This oil was not applied to the finished concrete surface, as in experiment No. 1, but later Harrison Ave. was oiled by the town with a light petroleum product and at that time the bridge surface was also oiled.

SUMMARY.—When last inspected, on Jan. 21, both of these bridge surfaces were in good condition. The Paramus Road Bridge showed a rather rough mosaic surface, free from cracks. The covering of oil, sand, and screenings had been largely pushed to the sides and a considerable amount of mud had been deposited upon the surface by passing vehicles. The approach at the west end had been badly rutted by heavy traffic and the beginning of the concrete had spalled somewhat at this point because of the impact of vehicles. There was no evidence of cracks, but two small spots appeared rather soft when scratched with a knife. The Harrison Ave. Bridge was in excellent condition when inspected at this time. An oil-earth mat about three-sixteenths inch thick was evenly distributed over the surface and there was no evidence of cracks where this mat was scraped away. At these places, however, the concrete appeared somewhat soft under a knife. Both approaches were in excellent condition and no spalling was noticed at the juncture of the road and bridge surfaces. Apparently the traffic over this bridge is not as heavy as over the Paramus Road Bridge.

It was a difficult matter to obtain the exact itemized cost data for these experiments because of the fact that the foundation and the wearing surface were laid almost simultaneously. Table IX. shows, however, the approximate cost of the wearing surface of oil-cement concrete.

Forest Fire Prevention in Oregon.*

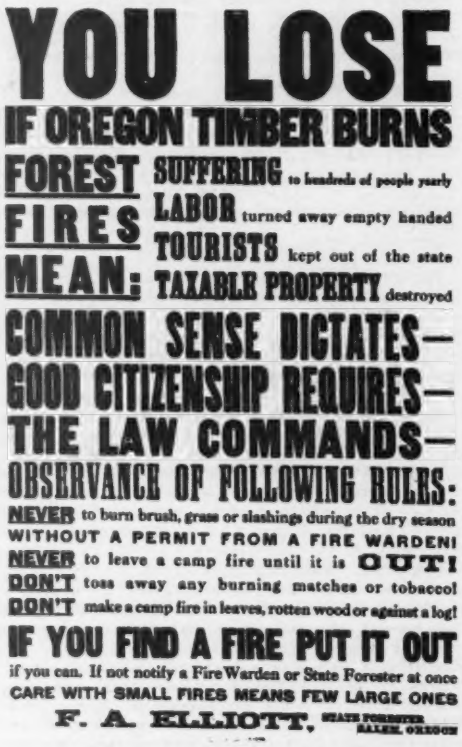
Oregon is estimated to have one-fifth of the standing timber left in the United States; about 500,000,000,000 ft. B. M. The estimated stumpage value of this timber is $600,000,000. Last year approximately 1,750,000,000 ft. were destroyed by fire, valued at $2,000,000 in stumpage alone. Over 1,000,000,000 ft. of this was on private lands outside of the National Forests. During the fires of last summer, six human lives were lost and many settlers' homes destroyed, and their live stock killed. To remedy the conditions which have made possible such losses the legislature of Oregon has recently passed a stringent forest fire law. An abstract of its more important provisions are given below. We also reproduce a cloth notice, 12 x 18 ins. in size for posting on trees, etc.

Section 1. There shall be a State Board of Forestry, consisting of the Governor, the acting head of the Forest School of the Oregon Agricultural College, and five electors of the State of Oregon, to be appointed by the Governor from and upon the authoritative recommendation of the Oregon State Grange, the Oregon Forest Fire Association, the Oregon and Washington Lumber Manufacturers' Association and the United States Forest Service, and Oregon Woolgrowers' Association, each to select and name one of such electors.

Section 2. The State Board of Forestry shall appoint a State Forester, who shall be a practical forester familiar with western conditions and experienced in organization for the prevention of forest fires. He shall hold office at the pleasure of said Board, which shall also have power to fix his compensation at not to exceed three thousand dollars ($3,000) per annum. He shall, under the supervision of the State Board of Forestry, appoint and instruct fire wardens as provided for in this act; direct the improvement and protection of state forest lands, collect data relative to forest conditions; take such action as is authorized by law to prevent and extinguish forest, brush, and grass fires; enforce all laws pertaining to forest and brush-covered land and prosecute for any violation of said laws; cooperate with land owners, counties or others in forest protection; advise and encourage reforestation; and publish such information on forestry as he may deem wise.

Section 5. Any and all inadequately protected forest or cut-over land adjoining, lying near, or intermingling with other forest land and covered wholly or in part by inflammable debris or otherwise likely to further the spread of the fire, which by reason of such location or condition or lack of protection endangers life or property, is hereby declared to be a public nuisance and whenever the State Forester shall learn thereof he shall notify the owners or persons in control or possession of said land, requesting them to take proper steps for its protection and advising them of means and methods to that end.

Section 6. All fire wardens appointed under this act shall, under instructions from the State Forester as to their exercise of state authority, take proper steps for the prevention and extinguishment of fires within the localities in which they exercise their functions, assist in apprehending and convicting offenders against the fire laws, control the use of fire for clearing land in the closed season as provided by Sections 7 and 8 of this act, and make such reports of their work and conditions within their localities as may be requested by the State Forester.


YOU LOSE
IF OREGON TIMBER BURNS
FOREST FIRES MEAN:
SUFFERING to hundreds of people yearly
LABOR turned away empty handed
TOURISTS kept out of the state
TAXABLE PROPERTY destroyed
COMMON SENSE DICTATES—
GOOD CITIZENSHIP REQUIRES—
THE LAW COMMANDS—
OBSERVANCE OF FOLLOWING RULES:
NEVER to burn brush, grass or slashings during the dry season WITHOUT A PERMIT FROM A FIRE WARDEN!
NEVER to leave a camp fire until it is OUT!
DON'T toss away any burning matches or tobacco!
DON'T make a camp fire in leaves, rotten wood or against a log!
IF YOU FIND A FIRE PUT IT OUT
if you can. If not notify a Fire Warden or State Forester at once
CARE WITH SMALL FIRES MEANS FEW LARGE ONES
F. A. ELLIOTT, STATE FORESTER SALEM, OREGON

Forest Fire Notices in Oregon.
(One-fourth size.)

Section 7. During the period between June 1 and October 1, which is hereby designated the closed season, it shall be unlawful for any person or persons to set on fire, or cause to be set on fire, any slashing, chopping, woodland or brush land, either his or their own or the property of another, without written or printed permission from a fire warden and compliance with the terms thereof which shall prescribe the conditions upon which the permit is given and which are necessary to be observed in setting such fire and to prevent it from spreading so that life or property of another may be endangered thereby. This restriction shall not apply to the burning of log piles, stumps or brush heaps, in small quantities, under adequate precautions and personal control, and in accordance with any regulations which may be adopted by the State Board of Forestry for the purpose of insuring public safety; but if any such burning without permission shall result in the escape of fire and injury to the property of another, this shall be held *prima facie* evidence that such burning was not safe and was a violation of this section. Violation of these provisions shall be punished by a fine of not less than $25, nor more than $500, or by imprisonment of not less than 10 days nor more than three months.

Section 8. Any person who sets on fire, or causes to be set on fire, any woods, brush, grass, grain, stubble, or other material being or growing on any land not his own, without permission from the owner, or who willfully or negligently allows fire to escape from his own land, or any one who accidentally sets any fire on his own land or another's and allows it to escape from his control without extinguishing it, or using every effort to do so, shall be punished by a fine of not less than $50 nor more than $1,000, or imprisonment for not less than one month nor more than one year; *provided*, that it shall be lawful to build, in a careful manner, camp fires on any uninclosed lands, the owner of which has not forbidden such building of camp fires thereon, if, before departing from the place where such camp fire has been built, the builder of such fire totally extinguishes the same; *and provided further*, that nothing in this section shall apply to the setting of a back fire, in good faith, to prevent the progress of a fire then burning.

Section 9. Any person who builds a camp fire upon lands within this state, not his own, without clearing the ground immediately around it free from material which will carry fire, or who leaves thereon a camp fire burning and unattended, or who permits a camp fire to spread thereon, or who uses in any firearms discharged thereon other than incombustible gunwadding, shall be punished by a fine of not less than $25, nor more than $500, and upon refusal or neglect to pay the fine and costs imposed shall be imprisoned for a period not to exceed one day for every two dollars ($2.00) thereof, or may be subject to both such fine and imprisonment at the discretion of the court.

Section 10. From June 1 to Oct. 1 of each year it shall be unlawful for any person, firm or corporation, or employee thereof, to use or operate any locomotive, logging engine, portable engine, traction engine or stationary engine using fuel other than oil, in or near forest or brush land, which is not provided with an adequate spark arrester kept in constant use and repair. Escape of fire from any engine shall be *prima facie* evidence that such appliance has not been adequately maintained in compliance with this section. Upon proof that any prosecution has been instituted under this section by any fire warden, any court of competent jurisdiction shall enjoin the further use of the engine involved, unless equipped and maintained in compliance with this section to the satisfaction of said fire warden, until the defendant has been acquitted of the charge preferred.

Section 11. All persons, firms or corporations engaged in logging, or permitting logging upon their lands, in this state, shall each year, burn their annual slashing, by which is meant the tops and inflammable refuse left after lumbering, that may carry fire or cause it to spread, at such time and in such manner and with such provision of help as will confine the fire to their own lands, and if such burning is done between June 1 and Oct. 1 shall first cut down all dead trees or snags over twenty-five (25) ft. high. Builders of trails, roads or railroads in this state, shall immediately destroy or remove all inflammable material resulting from constructing or clearing for such improvements unless prevented under the provisions of Sections 7 and 8 of this act. Any person, firm or corporation operating a railroad in this state with coal or wood fuel shall annually, or when so directed by the State Board of Forestry, and in a manner and to the extent directed by said board, destroy or remove all inflammable material from the right-of-way of said railroad, All burning under the provision of this section shall be in accordance with the provisions of Sections 7 and 8 of this act. The State Forester, with the consent of the Board of Forestry, may suspend the restrictions of this section when and where he deems public safety so permits or requires. *It is further provided*, that in the absence of such suspension, and in case of refusal or neglect by any person or persons at fault, after proper notice, to take the precautions against fire required by this section, the State Forester, or district fire warden acting with his consent, may have the work done to the extent he deems requisite to public safety, and the cost thereof and the expense of any fire patrol rendered necessary by the delay shall be recoverable from the offender by action for debt.

Section 12. Any person who shall unlawfully or maliciously set fire to any woods, forest, timber, brush or vegetable matter whatever with intent that the property of another shall be injured thereby, shall be guilty of a felony, and upon conviction thereof shall be punished by imprisonment in the State Penitentiary for not less than one (1) nor more than ten (10) years.

Section 13. In addition to the penalties provided in this act, the United States, state, county or private owners, whose property is injured or destroyed by fires in violation of this act, may recover in a civil action double the amount of damages suffered if the fires occurred through willfulness, malice or negligence; but if such fires were causes or escaped accidentally or unavoidably, civil action shall lie only for the actual damage sustained as determined by the value of the property injured or destroyed, and the detriment to the land and vegetation thereof. Persons or corporations causing fires by violations of this act shall be liable in action for debt to the full amount of all expenses incurred in fighting such fires.

Section 14. Any person not employed and compensated as a fire warden who shall detect any one violating any of the provisions of this act, and shall furnish information leading to the arrest and conviction of such person, shall, upon his conviction, receive one-half of the fine paid by such person so convicted, otherwise all fines imposed under this act, less the cost of collection, shall go into the general fund of the county in which conviction is had.

*From information furnished by Mr. E. T. Abbott, M. Am. Soc. C. E., General Manager, Klamath Lake R. R., Thrall, Cal.

Semi-Annual Convention of the American Society of Heating and Ventilating Engineers.

The semi-annual meeting held at the La Salle Hotel, Chicago, July 6 and 7 had a fair attendance, and about 30 new members were elected. The total registration was about 120 members and guests. Three sessions were held, at which half a dozen papers were presented and some topical subjects were taken up for discussion.

The most interesting matter was the presidential address by Mr. Richard P. Bolton, which discussed the total heat production of fuel combustion in New York City and the effect of this heat upon the atmospheric temperature and rainfall. An abstract of this we publish elsewhere, but the general conclusion was that the heat is sufficient to raise the temperature nearly 5° F. over the entire area of Greater New York (326 miles) to a height of one mile, and that it would increase the capacity of saturation of the atmosphere to an extent equivalent to the loss of about 0.03-in. of rain over the entire area. An increasing interference with natural conditions may be expected with the increase in population and fuel consumption.

The subject was discussed generally in connection with a later paper on "Smoke Prevention," by Mr. Paul P. Bird, formerly Chief Smoke Inspector of Chicago. Mr. Bird stated that he had estimated the annual coal consumption of Chicago at 10,000,000 tons, while Mr. Bolton gave 17,000,000 tons for New York; the per capita consumption in Chicago, therefore, is greater than that of New York (given by Mr. Bolton as four tons); this is accounted for very readily by the fact that Chicago has a much larger proportion of manufacturing establishments within the city limits.

In the discussion, Mr. Bolton noted that in New York the smoke problem is less pressing than in Chicago, owing to the use of hard coal, but the time is approaching when a depleted coal supply will make it necessary for New York to use soft coal. As not 1% of the boilers are fitted to burn a mixture of the two coals, and a much smaller proportion is fitted for burning soft coal, great changes will be necessary to adapt boiler plants to the new conditions. He referred also to the effect of smoke production upon natural light; records of the weather bureau show a decrease in intensity of sunlight west of New York; this is attributed to the blanket of smoke which hangs over "soft coal" cities in the night and acts as a veil to reduce the intensity of morning light until the smoke is dispensed by the wind. As a result there is a greater use of electric light.

In regard to adapting boilers to various grades of fuel, one member referred to the equipment of the New York steamer "La Grande Duchesse" with water tube boilers some years ago; such boilers were successfully used in stationary plants, but under the fuel and draft conditions of the steamer the solid flame sometimes extended many feet above the smokestack; the results were such as to lead to the change from water-tube to marine tubular boilers. As to the dirt and ashes discharged from smokestacks, it was estimated that these represented an annual quantity of some 10,000 tons in New York.

A paper on "Free Engineering" by Mr. Perry West and Mr. George W. Knight, pointed out that an owner relying upon a contractor or manufacturer for engineering advice does not get it free since it is included in the bill. Further, he does not get unbiased or disinterested advice, for it is to be taken for granted that the advice will favor one particular system, although perhaps some other system would be better adapted to the case. In the discussion, it was remarked that the engineer should hold to a proper code of ethics and not "cut rates" in order to get business. There was at one time an agreement arranged between this Society and the American Institute of Architects which provided that the owner should pay the engineer's fee in addition to the architect's charges. On the other hand, with any new system or device, the manufacturer may get better results by being allowed to plan the installation himself (or through his own engineers) than by turning the matter over to an independent engineer who may not be well informed as to the features or requirements for the best operation of the new system.

A paper on "Heating and Ventilating High School Buildings at Decatur, Ill.," by Mr. S. R. Lewis described a plant for serving two separate buildings with heat, ventilation and electric light and power, using the indirect system of heating and having a small turbo-generator plant. The connection with one of the buildings involved about 650 ft. of trench work for a 10-in. steam pipe, a 4-in. return pipe and a four-cell electric conduit. The placing of the fan in the attic was criticised by some speakers as likely to cause noise or vibration in the building, but Mr. Lewis said this would not be the case with proper supports and with a properly balanced motor and fan. One member instanced a case where a fan placed in this way in an old building was mounted on a platform carried by a steel column carried up from the basement quite independent of the building itself. The Decatur buildings have the flues so arranged that the air can be circulated in a closed circuit, the outlet and intake being closed; this method is used in warming the empty building before occupancy. It effects a substantial saving in fuel. This closed-circuit system was discussed at some length. Mr. Lewis referred to experiments which are to be made in a Chicago school by which eack desk will have its individual fresh air supply. The air will be delivered to a chamber formed by building a false floor, and from this chamber will be a vertical pipe rising to a point just below the book shelf of each desk. The foul air will be drawn off from another chamber formed by a false ceiling.

A paper on "A New Basis for Rating House Heating Boilers and Furnaces," by Mr. Frank L. Busey dealt with experiments made at the University of Illinois. The basis suggested is the horse-power developed per sq. ft. of grate. A paper by Mr. D. M. Quay described the ventilation of the basement of the Macy store in New York, the method being such as to maintain a comfortable temperature and a pure condition of the air. A paper on "Street Car Ventilation" by Mr. W. Thorn, referred to the trial of various systems in Chicago. These include the mechanical system (with either blowers or exhaust fans), and the automatic system which depends for its operation upon the movement of the car. Mr. Bolton remarked that the extensive trial and use of car ventilating systems in Chicago indicated a growing public demand that must be recognized. In New York, the city has provided for the ventilation of the subway tunnels, but nothing has been done to ventilate the cars themselves. It is true that some cars have been fitted with motor-driven fans, but these simply agitate the contained air and do not give any real ventilation. One other brief paper presented the results of some tests made at the Fire Underwriters Laboratories (Chicago) to determine the loss of heat from pipes carrying air at different temperatures, the pipes being clothed with different heat-insulating materials.

The operation and care of heating and ventilating apparatus was a topic which brought out some discussion, and it was made evident that many large plants are placed in charge of ignorant and incompetent men. A common condition is to find air intakes blocked; in one case, an intake chamber was assigned to the electrician as a tool shop, with the result that the intake openings were obstructed by benches, shelves, etc.; in another case, an intake tunnel conduit was used as a receptacle for old boxes and packing cases, and in a third case an intake chamber was utilized as a store for rubbish. In one case also, the attendant had shut off the inlet to the heating chamber and when asked his reason explained that it would be dangerous to allow cold air to pass over the hot pipes as it would crack the pipes.

Such conditions are specially liable to occur where employment is a matter of political preferment. Fuel economy in heating buildings may be obtained in many cases by keeping them warm night and day, instead of allowing them to cool off at night. In this respect the operation of greenhouse plants was noted; here the fires are banked during the day and worked at night, and the temperature variation is limited to 5°, while in other buildings the variation is often 30 to 35°. Several speakers cited instances where it was found that less coal was required to keep a church or office building at uniform temperature than to warm it only when required for occupation. As to house heating, it was estimated that 75% of house heating boilers are handled inefficiently and wastefully.

The relative merits of exhaust steam and live steam for heating purposes developed a brisk though brief discussion. It was remarked that the superiority claimed for the former is probably a matter of individual or local conditions and not of general application; also that this claim is made particularly by representatives of the vacuum system. This brought certain of these representatives to their feet, on the assumption that the statement was an attack upon the system; the speaker deprecated the idea, but expressed his satisfaction at having drawn out the explanations regarding the vacuum system. Mr. Bolton suggested that exhaust steam under vacuum was considered better than live steam under pressure.

Legislation for the compulsory ventilation of school rooms was discussed, particularly in regard to the Indiana law, which provides fine and imprisonment for trustees who build schools which do not comply with the law. Air-washing methods were discussed briefly. A matter which bordered upon the humorous was the mention of an inventor's scheme for obtaining a supply of cool pure air from the upper regions of the atmosphere by ducts attached to balloons. One member remarked that as some aviators had found the temperature above greater than that upon the earth, it would be necessary to seek a great altitude. The only other outcome of the suggestion of the inventor's idea was a wave of smiles and shrugs which materially lessened the tedium of the meeting.

One other subject which was discussed only briefly, but which is likely to demand much more attention in future, was the relation of vacuum-cleaning systems to the work of the ventilating engineer. One speaker explained that in Detroit it was proposed to apply vacuum-cleaning to all the schools, but the plans submitted by different firms indicated that the design is largely a rule-of-thumb matter and that the makers have little real knowledge of what they are doing or should do. In different machines designed for the same work the size of duct ranged from 2 to 15 ins., the vacuum from 2 to 26 ins., the power from 2 to 7 HP., and the weight from 500 to 7,000 lbs. Tests showed the unexpected result that in rapidity of work the vacuum cleaner cannot compete with the hand broom, at least in such places as a school room with fixed seats. Where it took 15 minutes to clean a room by vacuum cleaners, a man with a broom did it in 4½ minutes. Another speaker referred to exactly the same experience at Boston in a normal school which has a very elaborate system for vacuum cleaning. On making a visit to inspect this system, it was found that its use had been discontinued, as the janitor could do the work with a broom in 25% of the time, owing to the loss of time in getting the pipe, etc., around the fixed seats.

The above objection applies to time only, as it was generally admitted that the vacuum system is more efficient and also has the great advantage of not raising and dispersing the dust. In one case mentioned, the dust is drawn to a furnace chamber where it is consumed. We may note that at the new Chicago station of the Chicago & Northwestern Ry. the vacuum system collects the dirt and dust into a chamber from which it is flushed to a sewer. One member considered that for school rooms washing is far superior to vacuum cleaning, and that school buildings should be so designed as to allow of the washing out of the rooms with a hose. It seems evident from the discussion, that the increasing introduction of the vacuum cleaning system on a large scale will necessitate its careful study by ventilating engineers.

Water Rates.*

By GEORGE G. EARL,† M. Am. Soc. C. E.

There is a general awakening of the people of the country upon the subject of the charges made by public-service corporations, and a general widening of the scope of regulation of such charges by courts or commissions empowered to consider and revise them. As yet, the movement is in its infancy, but it has established a tendency toward a "square deal" for the patrons of these services and for their investors also.

If this tendency goes forward to its logical and desirable conclusion, exorbitant profits will not be permitted, but rates that guarantee a fair return will be established and maintained. These rates will not be permitted to be inequitable between different consumers, or different classes of consumers, or for different items of service. Before this condition is brought about there will be necessarily a revision of rates charged by practically all public-service corporations, which revision will be based upon a valuation of their properties, and an accounting of the cost of maintenance, depreciation and operation, properly subdivided to establish the fair return for each logical division of the service.

An ideal system of rates and of accounting for the establishment of rates, therefore, must determine the fair average cost of items of the same kind, and must collect that cost for each item entering into the service of each patron. The rates should not be based upon favoritism or the amount of good which the patron gets from the service, or the amount necessary to pay dividends upon excessive capitalization, though these are the only theories upon which many present rates can be defended.

Some public-service corporations are charging exorbitant prices for some particular items of their service, or to some class of patrons, while they may not even be getting a fair return from the service as a whole; and as a frequent result have the enmity of those who are being taken advantage of without usually the good will or confidence of those who are benefiting by their discrimination. Very often the fact that certain items of service are being charged too high, and others too low, is not even recognized by those who have blindly followed precedent in rate schedules, which have been copied from one to another without regard to governing conditions or even correctness of original deductions.

When only fair returns are allowed, then risk must be eliminated and fair returns must also be practically guaranteed. In growing communities, where the patrons are rapidly increasing, a fair rate at one time may easily become an exorbitant rate a few years later, when patronage increases, or a losing rate if prices or other conditions affecting the operation of the service change in the wrong direction. The rate, therefore, should be easily and equitably adjustable to meet these changing conditions, and a competent rating authority should have jurisdiction over the rates charged by all quasi-monopoly or public service corporations.

In order to determine rates that are fair according to service rendered, there must be a measure of service.

The water-works system that attempts to work on a flat-rate schedule cannot possibly do even approximate justice between its consumers, even those consumers who have the same rates applied to the same fixtures and conditions, because the personal element enters and cannot be eliminated, and the flat rate which averages right for a large number of families will be rank injustice to the careful consumer, and an equal injustice to the water purveyor in the case of the careless consumer.

Gas, electric, and to some extent, telephone companies, base their charges upon the quantity of service rendered and measured or recorded as it is given, and they are, as a rule, in a much more prosperous condition than water companies, being thus far also more free from attacks, although, so far as the writer can judge, their rates are more open to criticism on the ground of general or average overcharge than are water rates. A gas or electric company would not think of giving a flat-rate service similar to the ordinary flat-rate water service, yet the value of the gas and water delivered to the consumer per 1,000 cu. ft. is nearly the same.

Trials of flat rates for water, as first reluctantly recommended by the writer for New Orleans, very soon showed that the water consumption would go to over 300 gals. per capita per day under such a system, and that those consumers who were really fair in their use of water would have to pay over three times a fair price for the water which they actually used in order that their neighbors who wasted water might continue so to do, and that the very large consumers might get the benefit of the low cost per 1,000 gals. which goes with a large output from the plant. In addition to this, there was looming up, as a necessity of the very early future, the expenditure of large amounts for increased pumping capacity, filters, etc., and enlargements of the distribution system that would not be necessary for 15 or 20 years under fair use of water.

*A paper read before the American Water-Works Association, June, 1911.

†General Superintendent Sewerage and Water Board, New Orleans, La.

Under these conditions it was determined by the Sewerage and Water Board to meter all water consumers, even free consumers, and it became necessary to establish water rates for metered consumers. These rates had to be worked out to fit certain requirements of the law under which the Sewerage and Water Board was created, which requirements place a certain burden on the taxpayer as such, and a certain other burden on the rate payer as such, and since these burdens, as designated in this law, are obviously improperly distributed, leaving the taxpayer to carry a lot of load which the ratepayer should shoulder, and the ratepayer to carry a weight which clearly belongs to the taxpayer, there seems to be no use in describing in detail the way in which the subdivision of these loads was actually applied.

It happens, it is true, that the actual load carried by the taxpayers and by the ratepayers is, and possibly always will be, about fair under the New Orleans law, but that is only an accident.

The only factor in the New Orleans water rates as now existing that is worthy, in the writer's judgment, of perpetuation consists in the complete division between that which is done for the individual consumer and that which is associated with the general service of all ratepayers and taxpayers.

Every water-works keeps the account and makes the collection and reads the meter for the individual consumer. Most of them tap the water main for him. Some of them furnish the connection to the property line and maintain it, and some set and maintain his water meter. New Orleans does all of these things without any charge for placing the installation. These are an individual service. Their cost varies mostly with the size of the connection and meter. It varies also with the length of the connection and the conditions under which it is laid. It is not practicable to charge to each individual consumer the exact cost of the service which is performed exclusively for him, nor would it be desirable or fair. You have human nature to deal with, and if you try to deal on the basis of exact individual cost your consumer would say that he should not be penalized because he lived on the side of the street more remote from the water main, or because the paving or soil conditions are more difficult in his than in another's locality, or the weather conditions were unfavorable when his work was put in or the forces employed on his construction were less judiciously employed, etc., etc. Therefore, instead of determining the specific cost of keeping each account and making each connection and placing, maintaining and renewing each service line and meter, with the infinite labor of such accounts and the unlimited chance for favoritism, for errors and for injustice which such a system of accounting would entail, you so classify your accounts that you can determine the average cost for each different-sized connection and meter for the items above enumerated, or such of them as are applicable.

If a certain amount of annual payment is the average that is necessary to pay the interest on the first cost of a certain-sized connection and meter, and to maintain it in operation, and to eventually renew it, and to read the meter and keep the accounts and make the collection, then that amount, or that amount plus a fair profit, is a fair charge for this particular item of service, regardless of whether any water is used through the connection or not, or of the amount of water, or of the character of or amount of plumbing inside of the premises, or the number of premises, or of the uses to which the water is put. Later, a tabulation covering the New Orleans preliminary estimate of these costs will be given.

Having thus established a charge or method of arriving at a charge which takes care of connections and meters and accounting and collection, let us see what other charges should be made and how they can be arrived at under ordinary conditions of water-works practice.

The writer believes that a water-works system must be regarded as a cooperative enterprise. A separate system for large consumers or for small consumers or for fire protection would usually force higher costs for each. A given water-works system has a given capacity, and every consumer of water appropriates a certain proportion of that capacity, and each by his proportionate consumption hastens the date when an enlargement of the system will be required. Each in proportion to his use of water consumes fuel and coagulant, if these are used, and gets a proportionate benefit from every expenditure required to keep the system in operation. Having eliminated the cost of doing business with each, then, through the service charge, should they not all pay for the service received exactly in proportion to the amount of that service, i. e., to the amount of their consumption of water?

If you can ascertain the exact amount of water that you can sell, and the total cost of operating and maintaining the water-works system to the consumer's tap, the price per 1,000 gals. of water ought to be a question of division; and since the consumer pays, in his service charge, the cost of doing business with him, he should be regarded as upon the same basis as the patron of a "nickel in the slot" machine, to whom each nickel brings an equal return. There is less reason for one customer to get 300 gals. of water for his nickel than there another gets 1,000 than there would be for the large property owner to pay a lower percentage of tax upon his property than the small one, or the owner of 20 dogs to pay a less tax per dog than the owner of one dog, because in these cases the cost of collection and accounting does enter and is less for the owner of much property or many dogs than for their less opulent fellow citizens.

Let us now take an example and assume the necessary data and see whether a logical and easily adjustable system of making a water rate that shall be always fair to everyone can be devised.

Let us suppose that New Orleans, instead of passing her rather unusual and special law had done the more usual thing—that is authorized a board to use the city's credit for the construction of a water-works system with authority to issue bonds to the amount of the cost of the system, plus its going value until it could maintain itself, and to make water rates that would meet the interest on outstanding bonds, and maintain, operate and eventually renew the plant.

Let us assume, first, that we are going to do fairly between the taxpayer and the ratepayer; in other words, that the citizen pays out of his taxes and not out of his water rates for those public and charitable uses of water by which he benefits as a taxpayer whether he is a ratepayer or not. If the public authorities and departments and charitable institutions are themselves rate payers to the water department on the same basis as other consumers, their interest in the economical uses of water will be greater. So from the general tax fund there should be budgeted to each such department in some manner an amount sufficient to meet its water rates.

Let us examine the existing New Orleans data and see if we can arrange a system of division of actual expenditure from which we can determine:

(1) A fair fire hydrant rental.
(2) A fair service charge for each given size meter and connection.
(3) A fair price per 1,000 gals. of water.
(4) A fair amount to be raised by taxation.

Assume total cost of water-works system....		$8,500,000
Of which meters and connections to property line cost		$750,000
Assume that remainder of system is one-fourth for fire protection.....		1,940,000
and three-quarters for other uses.....		5,810,000
The population is	340,000	
Roughly, there are	515 miles of mains,	
and	5,000 fire hydrants.	
and now in use	25,000 meters and connections,	
out of a possible	60,000 required to	
serve the	80,000 premises of the city.	

	Gals. per day.
Assume sum of all meter readings to private consumers equals	7,000,000
Assume under-registration 20%.....	1,400,000
Assume sum of all meter readings to public and charitable institutions.....	3,000,000
Under-registration, 20%	600,000
Assume use through fire hydrants by Fire Department and Department Public Works.	2,000,000
Assume leakage waste and flushing out on 515 miles of mains.....	2,000,000
Average total present consumption.....	16,000,000
Nominal capacity of plant.....	45,000,000
Maximum capacity filters.....	67,000,000
Pumping capacity into distribution system..	100,000,000
Capacity distribution system at effective pressure	80,000,000

It will appear from the above that the present water-works system is greatly in excess of the needs of its present patrons, and if the consumers of the 7,000,000 gals. of water which is recorded to paying consumers had to pay water rates that would cover interest, depreciation and all expenses of maintenance and operation, their bills would be so high that they could not afford to take the service.

Assume the expense bill to be met to be as follows:

(1)	Interest and depreciation on cost necessary for general system = 4½% on $5,810,000..	$261,000
(2)	Interest and depreciation on additional cost due to fire system = 4½% on $1,940,000...	87,000
(3)	Interest and depreciation on cost of meters and connection, and cost of maintenance of same (25,000, cost $750,000), say.....	60,000
(4)	Cost of meter reading and collection and accounting on water rates, say.....	40,000
(5)	Cost of maintenance of distribution system.	50,000
(6)	Cost of maintenance of fire hydrants and connections to same.....	10,000
(7)	Cost of maintenance and operation of the pumping and purification plant, say output cost $70,000, capacity cost $80,000—total..	150,000
	Total.....	$658,000

These figures are assumed, but are sufficiently within range of the truth to illustrate the method and effect of the division of expense contemplated.

To be charged to fire hydrants and fire protection and other public uses of water through hydrants we have:

All of Item 2.....	$87,000
All of Item 6.....	10,000
¼ of Item 5.....	12,500
2/14ths of output cost and ¼ of capacity cost of Item No. 7.....	10,000 / 20,000
	$139,500

$$\frac{\$139{,}500}{5{,}000} = \$28 \text{ per hydrant} = 4\text{1c. per capita of population.}$$

To be charged as a service charge fairly pro-rated to each different-sized meter and connection, we have:

All of Item 3	$60,000
All of Item 4	40,000
	$100,000

To distribute this item between public and private consumers correctly would require the application of the proper service charge to each service. To approximate a division, however, for this paper we will assume a division in proportion to consumption as reaching approximately the same results, i. e.:

$100,000 × .3 = $30,000 = public consumers.
100,000 × .7 = 70,000 = private consumers.

To be charged to metered consumers against 10,000,000 gals. per day of meter record you have 12,000,000 gals. of water, or 12/14ths of the supply which is usefully employed, since leakage and waste from and flushing out of the distribution system have lost 2,000,000 of the total 16,000,000 gals. of supply. To this account must be charged as follows:

All of Item 1	$261,000
2/14ths of Item 5	37,500
12/14ths of output cost and 2/3ths of capacity cost of Item 7	60,000
	60,000
Total water charges	$418,500

$418,500 × .3 = $125,550 = public consumers.
418,500 × .7 = 292,950 = private consumers.

Dividing these expenses between the taxpayer and the ratepayer, we have as follows:

	From fire hydrants.	From service charges.	From water charges.	Total.
From taxpayers	$139,500	$30,000	$125,550	$295,050
From ratepayers	....	70,000	292,950	362,950
Totals	$139,500	$100,000	$418,500	$658,000

The total from water charges of $418,500 applied to a 10,000,000-gal. consumption recorded through meters requires a rate per 1,000 gals. of 11.5 cts., which is very close to the average rate now actually collected from consumers of pay water, because while the New Orleans rate is 10 cts., there are enough small consumers using less than their minimum allowance of 40,000 gals. per year to raise the average payment from the 10 cts. per 1,000 gals., as now fixed, to about 12⅛ cts.

The $362,950 total payments from ratepayers, and the $295,050 total payments from taxpayers are just about equal to their present payment under existing rate.

The following tabulation shows the values that have been assumed at New Orleans for determining the service charge for ordinary connections and meters. It will take several years to determine the adequacy of these service charges. The tabulation is submitted as a system of blanks to be correctly filled for each special case:

Material of service	Lead					Cast-Iron			
Size meter and connection, ins.	⅝	¾	1	1½	2	3	4	6	8
Cost of connection	$10	$10	$15	$43	$70	$60	$60	$90	$120
Cost meter in place	15	20	25	45	65	100	200	400	650
Total cost installation	$25	$30	$40	$90	$135	$160	$260	$490	$770
Annual cost to pay interest and to maintain and renew services	1.00	1.00	1.50	2.00	2.75	4.25	6.00	9.00	12.00
Annual cost to pay interest and depreciation and renew meters	1.50	2.00	2.50	4.50	6.50	10.00	20.00	40.00	65.00
Annual cost to cover meter reading, accounting and collection of water rates	1.50	2.00	2.50	4.00	5.25	7.75	10.00	15.00	20.00
Total annual charge	$4.00	$5.00	$6.50	$10.50	$14.50	$22.00	$36.00	$64.00	$97.00

With an established tabulation like the above, only much more in detail, comparisons of one city with another could be made, and all kinds of adjustments for changes in size of connections and meters could be made as required and rates for a small meter on a large service, or a detector by-pass meter on a fire service, or any other combination desired.

When property is vacant in New Orleans the service charge is remitted; otherwise the city assumes that the property owner who had the city invest anywhere from $25 to $770 in a meter and connection to furnish his property with water was in earnest when he applied for his connection, and he is required to pay his service charge whether he uses water or not, except that his service or meter can be removed if he reimburses the city for the cost of the original investment, plus the cost of the removal, less the value of the material removed, less a fair discount for the time during which the service has been in actual use.

Eventually we may try to get a tabulation of average costs to cover removals and salvage, etc.; or it may prove best to hold the service charge high enough to cover the cost also of such changes in size of meter or connection as may be required, or changes in location of connection, etc., where a property is destroyed and rebuilt upon different plans or for different uses.

Your next blank is the cost (or the cost plus a fair profit) per 1,000 gals. of water recorded as passing through the consumers meter, which may be anything, say from 30 to 3 cts. It seems to be 11.5 cts. in New Orleans now; when the consumption reaches 45,000,000 gals. it will probably be under 6 cts. It is recommended to hold it for the present to 10 cts., as additional consumption will soon equalize this rate. Then because of under-registration of meters when the stream passing them is too small to register, you can properly establish a minimum amount of pay water for each given-sized meter. These amounts as recommended for New Orleans, for ordinary meters, are as follows per annum, being the service charge, plus 10 cts. per 1,000 gals. for the specified amount of water:

Size of meter and connection, ins.	Limitation of service.	Gals. of water per year allowed at stated minimum rate.	Cost per year.	Cost per 1,000 gals.
⅝	Serving not over two persons and rooms	10,000	$5.00	$0.50
¾	Serving not over three persons and rooms	20,000	6.00	0.30
⅞	Serving not over four persons and rooms	30,000	7.00	0.23⅓
⅞	No limitation	40,000	8.00	0.20
¾	No limitation	50,000	10.00	0.20
1	No limitation	65,000	13.00	0.20
1½	No limitation	105,000	20.50	0.20
2	No limitation	145,000	29.00	0.20
3	No limitation	220,000	44.00	0.20
4	No limitation	360,000	72.00	0.20
6	No limitation	635,000	127.00	0.20
8	No limitation	970,000	194.00	0.20

As consumption increases beyond the amounts stated the total cost per 1,000 gals. is automatically decreased until in the case of the very large consumer the "service charge" becomes so small a factor that the actual total payment approximates but never quite falls to the 10 ct. actual "water rate."

If a compound meter is used, or any kind of reliable detector, the size of the by-pass meter should govern the minimum amount of water to be paid for, and size of main line the service charge. If under-registration on small streams could be avoided there would be no excuse for any minimum rate of pay water at all.

It will be noted that in the above schedule of water rates the term "service charge" does not appear at all; and in framing the printed charges it may be best to present just as few points for discussion and criticism as possible. A minimum annual bill for a given-size meter and connection, with a flat price per 1,000 gals. of water in excess of a stipulated quantity, will probably best meet this condition, said minimum being applicable just as well to a metered fire service as to any other form of service.

The writer's idea in stating the rates as above, however, is that they are in the simplest possible form, and he would keep their method of creation close for explanation to any citizen who wished to understand the reason for them or for the correction of any inequity which, exactly as stated, they might possibly work in exceptional cases.

Having applied the proper service and water charges to every possible consumer that it is practicable to meter, including all public institutions, the water-works has only to collect the fair fire hydrant rental, and the city to adjust the tax rate to reimburse itself for water rates to be paid by taxation.

The figures given throughout, remember, must be right, and just as fast as experience warrants they must be changed and kept right. No one can fairly complain. The small consumer will not care to because he is usually benefited. The large consumer, in some cases, will have his bill raised, but in such cases he ought to be very grateful that the new rate is not retroactive.

Public and charitable institutions supported by taxation would be metered and would pay the same water rates as private consumers, and would get money to pay them from the tax fund by budget. Their uses of water could then be compared with each other, with similar services elsewhere, and with private consumers, and they would have the same interest as other consumers in keeping their consumption within reasonable limits, while the public who paid in taxes for this and for water for fire hydrant uses could know exactly the status of these uses, and would be certain that given a fair valuation of property the contribution of each property through taxation was an equitable proportion.

The contribution by taxation for New Orleans now, under the above scheme, would be .00123% on the assessed value of $240,000,000 in which every taxpayer would share, every dollar of which would go to purposes for which taxpayers, independent of whether they were ratepayers or not, should contribute, this contribution being as equitable at least as those they now make for other public purposes.

The example here is of an over-built system at the very inception of its operation, when its consumption is under one-third of its easy capacity. As a consequence its capacity cost greatly overbalances its output costs, and the rate that has to be charged per 1,000 gals. of water is high, and big consumers especially complain.

The system was designed to serve a growing city of 340,000 population at the date of its completion. In the light of water consumption elsewhere, and with uncertainty as to whether the all-meter system could be carried through, 45,000,000 gals. did not seem too high a capacity to build, especially in view of the fact that the old water-works company, with only 7,000 connections on 125 miles of mains, often pumped over 20,000,000 gals. and the new system was to cover 500 miles of mains, upon which there were 80,000 premises.

Looking forward a few years, and assuming an average daily consumption of 45,000,000 gals., let us see about where water rates made up as advocated would go, assuming $800,000 spent in construction in minor extensions to the distribution system, and increased connections from 25,000 to 75,000 and fire hydrants to 6,000, with following division of water consumption:

Private consumers' meter readings, say	27,000,000
Private consumers' under-registration, 20%	5,400,000
Public consumers' meter readings, say	5,000,000
Public consumers' under-registration, 20%	1,000,000
Uses through fire hydrants, say	3,600,000
Waste and flushing distribution system, say	3,000,000
Total consumption daily	45,000,000

Working out as before upon the above assumption and tabulating costs chargeable to taxpayers and ratepayers, we have, as follows:

	For hydrants.	For services.	For water.	Total.
Taxpayers	$173,800	$43,750	$87,200	$304,750
Ratepayers	....	236,250	473,000	709,250
Total	$173,800	$280,000	$560,200	$1,014,000

By this time the city will have grown in population to, say, 500,000 at least. The assessed valuation will have increased from $240,000,000 to, say, $430,000,000, and the taxpayer's rate will have dropped from .00123% to below .0007. The rate per 1,000 gals. of water should have dropped gradually from 11.5 to 4.8 cts., while the price per fire hydrant upon the assumptions made remains about the same, and the cost per capita for fire protection would have decreased from 41 cts. to 35 cts. per year.

Of course, as the time approaches when the nominal capacity of the plant is fully utilized it would be best to hold up all taxpayers and ratepayers' rates sufficiently high to average off the increase in same that would otherwise come when additional plant had to be constructed. It is easier and more popular to lower rates than to raise them, so the water-works manager should look ahead enough to keep his rates a little on the down-grade even through peaks of considerable new construction that would otherwise necessitate an increase.

Specific instances of rates are best as illustration, so let us consider a typical modern house in New Orleans under fair rates and under the old water-works company's rates, viz., a 12-room house, with 5 persons, 18 openings, 50-ft. front lot, sprinkling privilege, etc., and assume its actual water consumption at 70,000 gals. a year, ⅝-in. meter and connection; assessed at $5,000. On the suggested plan the bill would be made up as follows:

Service charge	$4.00
70,000 gals. water consumption at 10 cts.	7.00
Total water bill	$11.00
Tax .00123% on $5,000	6.15
Grand total tax and water bill	$17.15
Cost per 1,000 gals. of total consumption, including tax	$0.25
Cost per 1,000 gals. of total consumption, excluding tax	0.16

With the flat rates in vogue by the old water-works company prior to 1900 this house, using this quantity of water, would have had to pay an annual water bill of $105, amounting to $1.50 per 1,000 gals.

After the company had been relieved of its franchise by the courts on the grounds of inequitable rates or discrimination this house could have had a flat rate of $74 a year, or $1.06 per 1,000 gals., or it could have paid a high price for and ordered a meter installed, and by paying 25 cts. per 1,000 gals. for not less than 20,000 gals. a month it could have had water for $60 a year or 86 cts. per 1,000 gals. for water actually required.

With the company the consumer paid $5 for a tap and paid a plumber to make and maintain his connection.

Notwithstanding these rates the company was only getting 6 cts. per 1,000 gals. in total revenue for all of the water it pumped because nearly all of its consumers were on flat rates, and most of them had a grouch against the company and tried to see how much water they could waste, overlooking the fact that this waste was what made the company's pressure so bad that a connection from its mains often would not feed the second story of houses remote from the pumping station. Some of these consumers were actually getting their money's worth in quantity of water whether they had use for it or not, and some few of those who really had use for the quantity which they were drawing, i. e., very large consumers, are paying now a higher water bill than they paid to the old company and complaining because the city will not give them a 5-ct. rate.

The writer has made a comparative study for New Orleans to see about how much difference there really would be in its case between "all meters" and the ordinary flat-rate schedule, and he is convinced that, assuming every premises in the city to-day connected with a water-works system that was constructed and kept ten years ahead of its capacity requirements, there would be an annual saving by the meter system to the tax-payers and rate-payers of the city, all told, of at least $450,000 a year, or over $1,200 a day. With present population, with meters the consumption would be, say 28,000,000 gals., and with flat rates the consumption would be at least 80,000,000 gals. per day, and the large consumers could have a very low price per 1,000 gals. of water, while the conservative small consumer who prevented waste would pay for his neighbor's waste and for the large consumers' advantage over three times his present bill to cover extra coal and congulant and extra labor and interest requirements for unnecessary extensions to the water-works system, in which luxury the tax-payer would share.

The small consumers and small tax-payers are in the majority in all of our cities, and they are beginning to study the rates which they are paying and to ask a reason for any seeming inequity, and wherever they find a real or fancied injustice to themselves they are agitating against it with voice and vote, so that in some cases the reaction is going to the opposite extreme and certain classes of small consumers are getting rates below the fair cost of the service rendered to them.

No one now would defend a railroad rebate; it is recognized as an evil which has worked untold injustice, and is now outlawed. The shipper who received no rebate was being taxed a higher rate for the benefit of the rebated shipper. This is only another way of saying that one paid more than a fair return for the service rendered, and the other less, and reduces itself to this, viz.: *That no single item of service rendered by a quasi-monopoly or public-service corporation can be charged for at a price higher than the fair average cost of all of the items of this kind performed by it, plus a reasonable profit thereon.*

The power to limit gross receipts to a fair return is now admitted everywhere. If the gross receipts are reasonable but certain items therein are charged at an excessive price, then the class of patrons paying for these items is obviously being discriminated against in favor of some other patrons, which is exactly what rebating is, a tax upon some to their detriment for the benefit of others.

The usual telephone rate sheet in almost any city seems to present aggravated examples of rates per item of service which bear no relation to the cost of the service rendered in said items. These rates as a whole may not yield more than a fair return, but if they do not then the tax which they impose upon some for the benefit of others seems to be excessive.

Take, for instance, a residence rate for an unlimited service, and direct line, which costs, say, $48 a year. One residence may contain 20 people who keep the 'phone busy constantly, say with an average of 20 calls a day. Another residence contains only six persons and has six calls average per day. Residence No. 2 has to pay exactly the same as No. 1 for one-third of the service. Again, take house No. 2 with six people and six calls a day, but instead of one family assume two families living together each of whom want a name in the telephone book, same equipment, same number of calls, but they are confronted with this: "extra name in book, $12 per year," of which about $11.75 is profit to the telephone company on an investment of nothing. Or again, house No. 2, with a partial invalid at the head of the house wants an extension set up-stairs, which cannot cost over $5 to install nor over 50 cts. a year to maintain, but it costs, once more, $12 a year, or say $11.50 a year income on a $5 investment.

Obviously, these charges are based upon the necessity of the patrons and not in any sense or degree upon the cost of the item of service to the company, and in each case they help to pay for an under-charge which is made to some other class of customers, or else they swell an unreasonable profit.

In the writer's view there is a great procession forming in this country; it carries numerous banners with many mottoes: the banner in front cries for the "square deal"; another calls for the "conservation of natural resources"; another says "no more rebates"; another, "equal rights to all, special privileges to none," and so on down the line, in a thousand different wordings, invented by a public conscience which has been awakened in various ways, often possibly by personal failure in an opposite course, to a general belief that after all, "honesty is the best policy."

The water-works fraternity has much to gain and nothing to lose by joining this procession; water rates are, generally speaking and as a whole, low—they are often inequitable, and so subject to destructive attack. Would it not be better to give some real study to the question of how to establish and maintain a fair rate so certainly that the courts and even the majority of the people will recognize it, and thereby get into a position that will assure, through universal metering, reduced total payments by rate-payers and tax-payers, and at the same time fair returns for water service, and in so doing promote stability in water enterprises and the good will of the great majority of the consumers—so far at least as uniformly fair treatment can induce good will?

The "square deal" army is forming in every city and hamlet and cross road in the country. Those who are wise enough to paste Mr. Hubbard's "Do it now" motto over their hat bands can safely mingle with this procession—may even "follow it in front," while those who believe that they can reap a permanent advantage by an opposite course are more than tempting fate.

The writer does not claim that he has worked out this system perfectly in the example assumed, but he asks earnest consideration of the principles involved as suggesting a general line along which a logical rate system can be established which will allow of comparisons between rates in different cities through the comparison of the items entering into their determination, as ascertained by such a uniform division of accounts as would be required to serve as a basis for the determination of rates.

A Portable Cofferdam.

By H. B. McDERMID.*

At the power station of the U. S. Reclamation Project at Minidoka, Idaho, supplying power for irrigation pumping, are five 2,000-HP. main units all fed from a common forebay. There

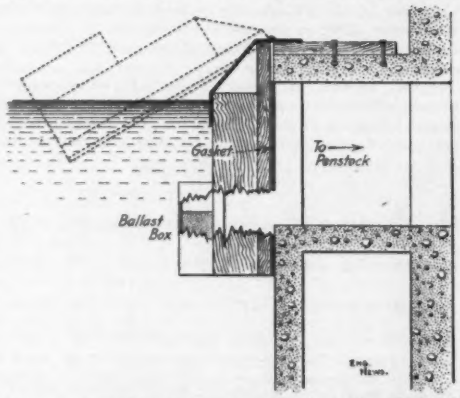


Fig. 1. Portable Cofferdam Used at the Minidoka Power House; U. S. Reclamation Service.

was no need of all the apparatus at the time when the first unit became necessary, so that the other feeder openings were closed by stop logs and the water above the dam was raised to normal operating head. It finally became necessary to complete the work about the station by installing the headgates and trash racks of the other four units and it was necessary to do this work without interfering with the operation of the unit in service. Lowering the level of the lake was therefore out of the question. The problem was to keep the main bays of each unit free from water while installing the gate valves, and it was solved by the engineers of the Reclamation Service in a novel and interesting way. A cheap, portable cofferdam was built to cover, in turn, each of the openings in which work was to be done. After the openings were covered, it was possible to cut through the stop logs and unwater the opening, thus allowing work to be done in between the cofferdam. As the gate frames were quite large (12 × 12 ft.), the cofferdam was built to cover approximately 16 × 20 ft. of the straight vertical concrete wall which forms both the dam and one wall of the power-house, through which the penstocks lead. It was in effect, a large shallow box, about 4 ft. in depth to allow of plenty of room in which to handle the five-ton gate, its equally heavy frame, and the trash racks, and was built of 12 × 12-in. timbers with the seams carefully calked. The inner surfaces of the timbers coming in contact with the dam were heavily padded with waste, enclosed in strong canvas, firmly tacked on. This formed an effective gasket about 4 ins. thick when compressed in service. This satisfactorily covered any small irregularities in the wall and prevented serious leaks about the contact between cofferdam and wall.

The whole device was supported in position by a pair of heavy hinges fastened to timbers bolted to the top of the main dam. This allowed the cofferdam to be swung away from the main dam, as shown by the dotted lines of Fig. 1, when preparing to move it from one penstock to another.

A large box was hung on the outside of the cofferdam to be filled with sand or gravel for sinking the outer end and swinging the cofferdam up against the wall of the dam. This box had a trap door bottom which provided a handy means of emptying, previous to floating the outer end.

In operation, the device was towed, floating flat, up to the penstock opening which was to be covered. The upper end was raised by a 15-ton derrick, serving the forebay, until the hinges on the cofferdam could be fastened to the mates on the dam, which had been previously mounted on timbers securely fastened to the dam by heavy foundation bolts.

The cofferdam then lay as shown in Fig. 2, at an angle of about 45° to the vertical and with one end floating. The ballast box was next filled until the end sunk and the cofferdam swung forward against the wall. The stop logs of the penstock openings were cut through and a 2-in. siphon pipe was placed to carry off water from small leaks during erection of the gate and racks. This 2-in. pipe was usually sufficient, but when a larger pipe was used, its lower end was throttled so as to keep the water in the cofferdam pit at a desired level and to prevent running the siphon dry.

When ready for removal, the pressures on each side of the device were equalized by opening a small filler gate and the ballast box was dumped. Then a slight pull was sufficient to cause the lower end to swing outward to its natural floating position. The upper end was next lowered by the derrick until the whole apparatus lay floating on the water and the cofferdam was towed to the next place.

Throughout the work this scheme was found to serve its purpose effectively, conveniently and cheaply.

FIG. 2. PORTABLE COFFERDAM READY FOR SINKING.

*Erecting Engineer, Allis-Chalmers Co., U. S. Reclamation Project, Minidoka, Idaho.

Reminiscences of Pioneer Railway Building in the West.

By AUGUSTINE W. WRIGHT, M. Am. Soc. C. E.*

The past few years have witnessed the passing away of many of those hardy engineers who endured hunger and thirst, heat and cold, and risked life itself, in order that the first railway lines across the continent might be constructed. There can never be a more exciting chapter in the annals of engineering than the story of peril and hardships and achievement of these pioneer scouts of civilization.

The writer was a member of an engineering party which was organized at Junction City, Kansas, in April, 1867, to survey a line for the Union Pacific R. R., from near that point to Denver, Colo., under Col. William H. Greenwood, Chief of Party and Henry R. Holbrook as his principal assistant. The party went by rail to the end of the track at the Saline River, and went into camp; and to this day, the writer retains a vivid recollection of that first night in camp. It was a bitter cold night and the blankets had been overlooked and left at Junction City. There was no wood to build fires. During the night about six inches of snow fell, and in the morning the various members of the party were obliged to kick around in the snow to find sufficient "buffalo chips" for a fire to cook breakfast, and the chips when found were so damp that it was several hours before breakfast was ready; by that time our fingers were so benumbed by the cold that they could not hold the knives and forks. Such was my initiation into the life of the pioneer engineer.

We located a line from Fort Ellsworth to Fort Harker and made preliminary surveys to Denver. By that time the company had decided to survey through to San Diego, Cal. Five parties were engaged; two on the 32d Parallel route, one under L. H. Eicholtz, who died recently in Denver at the age of 84 years, the other under John Runk, Jr.; and three parties on the 35th Parallel, one under Henry R. Holbrook, another under Howard Schuyler, and the third under J. Imbrie Miller. That division of the Union Pacific was never built beyond Denver, but the Southern Pacific ultimately used the 32d Parallel route and the Atchison, Topeka & Santa Fe the 35th Parallel. Of th's latter road Mr. Holbrook was later Chief Engineer (of the part then known as the Atlantic & Pacific R. R.), and in 1880-1882, he had the satisfaction of actually building a railroad over substantially the route which he had surveyed in 1867.

These surveying parties were frequently attacked by Indians; and they worked with their weapons always at hand. The dangers run by these early surveyors can be appreciated when it is remembered that large portions of the Union Pacific were afterwards built under military protection, and that even then work trains and labor gangs were frequently attacked by the hostile tribes. Yet these intrepid engineers often worked alone, reconnoitering the country miles away from their parties. It was fortunate that at that time men were available for such perilous duties who had had experience and had proved their mettle by the great civil conflict which had just closed.

Such a man was Howard Schuyler. Born in Ithaca, N. Y., in 1844, he had removed with his parents to Kansas, in 1859, when that state was seething with the tumult of border warfare. In May, 1861, when but 16 years old, he enlisted in the Union Army as a private soldier. He was twice, within a year, appointed First Lieutenant for bravery in the field, and each time declined because of his modesty on account of his youth and inexperience. He was finally made captain of a company of colored troops which he brought to high state of discipline and efficiency. At the close of the war he refused a commission in the regular army, and began work in the field on the Pacific railways surveys. Beginning as a rodman he was rapidly promoted and became Locating Engineer on the Kansas Pacific Ry., while the road was being constructed between Lawrence and Topeka, Kan. After the completion of his work west of Denver he returned to take charge of the location surveys of the Kansas Pacific Ry.

I have in my possession one of Mr. Schuyler's letters written 42 years ago, telling the story of one of his narrow escapes while engaged on the Pacific railway surveys. It may interest young engineers of the present day to have a glimpse of the life of a pioneer engineer only two-score years ago:

Camp on Sandy Creek, near Lake Station Colorado.
Oct. 1st, 1869.

My Dear Bunky:

You make me shiver by asking me to tell you the story of my late unpleasantness with "Lo." You can hardly imagine how tired I am of the story. I have told it already in all the different shapes that veracity will allow—plain and in colors. I had some thoughts of having it printed to keep a few copies by me; and when asked for the story, produce the printed slips, but have had no opportunity!

I have been congratulated from Vermont to Oregon "on my fortunate escape"; and when I thought and hoped it had been forgotten, it is revived from London and Naples. I never dreamed how many friends I had until this occurred, and after all it was no more than happens yearly upon the Plains! All, it is true, are not so fortunate as I; *their* escapes are unwritten and unread. It was sufficiently wonderful, it is true—marvelous—but not so rare.

You are almost the only one, my dear boy, who could induce me to tell it again; and to you the simple facts are all I can tell—your own knowledge will supply all that I omit; and I confess to you, what it is unnecessary to say to all, that I was scared—badly scared! You may not know what that means, so I would not have you whisper it to all your friends; but I tell you, that when those Red Devils first jumped me, in that rough country, and I realized that I was three miles from my party, alone, with only twelve shots about me—my heart suffered sudden displacement, and I felt as I never want to feel again—like a coward! Thank God it did not last long; but it was long enough for me to realize what the sensation is that drives the blood from a man's cheek and brings the cold, clammy moisture to his face!

You remember our old camp on the North Fork of the Smoky Hill River, where the "mokes" routed out the Indian body? We were running a line from there across the rough country, back to the Divide, north of Monument Station where our camp was burned two years ago, and had reached a point north of Sheridan, about 15 miles. We had just got out to work in the morning; and I had strolled along, dismounting occasionally to build mounds.

The country was rough and puzzled me just enough to keep my attention from everything else. I crossed some ravines and rode up on a little knoll. Suddenly my horse snorted, wheeled like a flash, and I saw coming out of the ravine I had just crossed, and not more than a hundred yards away, a band of Indians, their horses lashed to fullest speed!! They were between me and my party. Their evident intention was to make me run in an opposite direction. I comprehended this at a glance, and knew that it was sure death. My only chance was to reach the line wagon.

When I turned they had opened fire with their revolvers and arrows, and, while I thought I was passing them, scarcely 30 yards away, my horse running nobly, clearing the ravine like a deer, they closed in on my rear; but I could laugh at them there. My horse, though wounded, and bleeding profusely, was more than a match for any of their ponies. A quarter of a mile and I had left them 100 yards behind! I should reach the wagon easily and could afford a shot or two, perhaps, from the small store in my magazine.

A few more jumps, and here in my front, out of an unexpected ravine, dashing, yelling, swinging out on both flanks, rode the larger band! 40 or 50 to one!!

I had been drawn into a net; I was trapped; surrounded on all sides! Not an opening, but was filled with lance or rifle! It was horrible.

Bunky, we have both faced death very many times, and in different forms, when we had time to meet it calmly and manfully; and I think we never wilted under the ordeal; but it never came before me in such a hideous fashion as this. For a moment I suffered terribly; but our horses had not stopped all this time, and when I had unslung my rifle, it was to use it instantly. They had had easy work all this time, had wasted hundreds of balls and arrows and not a shot returned. I threw my reins loose, my gun dropped into the hollow of my arm, and one who stood in my front fell under my horse's feet. This excited me again.

Two more shots—both missed their aim. This was awful. Another miss would be my last. My nerves steadied, I pulled the trigger more carefully this time, and another Indian was out of my way. Instinctively the rest broke away from in front. My horse was keeping his long, sharp gallop. I was ahead again. But how long could I keep so? Their horses were comparatively fresh, mine exhausted and bleeding terribly from three deep wounds.

Not one had hurt me yet and I began to think lightly of their shooting. They followed me close; one shot struck my gun, partly shivering its stock; another cut off one of my spurs. They gained on me fast, and one whose horse's head lapped upon my flank emptied his revolver so close that I could feel the flashes; but only one ball struck my clothes. Then he drew his lance and struck me on the head several times. All this time I had tried to get him along side; but he kept at my flank.

It seemed to become a single combat now. The rest were keeping up close, but only an occasional shot. One of these struck my horse. He fell; but was up in a moment. The Indian had tried to check up a little but was too late! Quick as fate I shoved my rifle against his side and sent him to keep the others company on their journey to happier hunting grounds.

This stopped them all for a moment. They seemed to think I could not be killed. My "medicine" was far better than theirs. It was becoming a costly chase and they were inclined to give it up. Besides the party was in sight, only half a mile away. If my horse would only hold out I would make it yet. He was running slower and slower, trembling and weak; and seeing it they took fresh courage.

They were almost on me again. Five shots left with which to fight; yet half a mile on foot! How longingly I thought then of the pistols, left for the first time in my life in camp to be cleaned. With those I could hold out until help came; and life was becoming sweet at the last, since hope had so far revived. But the end was to be right here.

As the horse fell, I swung to the ground, turned quickly and caught the nearest "Red." He did not fall at once but clung to his horse for 40 or 50 yards. But it was enough; right and left the rest scattered, yelling and pounding their horses with lance and rifle, running faster than they came. I could scarcely realize it as they got out of range. I could hardly believe they had really gone and that I had only to make my way as slowly as I pleased to where the party was still in sight, merrily dealing out lead to other bands.

I turned to my horse, but he was already again on his feet. Noble fellow! He was still to live and do me good service. I almost cried as I took him by the bridle and saw the blood still pouring from him. He seemed to appreciate as well as I, that it was all over, and laid his head on my shoulder as if to ask if he had done his duty. God bless him!

You may imagine, Bunky, that his life won't know many more hardships, for he lived, and in spite of all, is living now and stands just outside my tent door, as full of life and fire, though not as sound, perhaps, as ever. I don't think he will ever forget, any more than I "that race for life."

Well, that is the story, told at much greater length than I intended to tell it. Though I try to forget it, whenever it is recalled, I can see distinctly the savage, exulting looks of the red devils when they thought their prey was sure, and can hear plainly the whiz and sing of every ball that came so close that only a greater than human power could have turned them away. The recollection is never pleasant. Good night!

Schuyler.

It is almost needless to say to the reader of the above letter that Howard Schuyler was brave to a fault, and was a most remarkable shot.

His younger brother, the well-known consulting engineer, James D. Schuyler, M. Am. Soc. C. E., was the only member of the party wounded in that fight.

He afterwards helped organize the Denver & Rio Grande R. R. Co., of which he was Chief Engineer and Treasurer. He left that company to become Chief Engineer of the North Pacific Coast R. R., and went from there to Mexico, where he became Chief Engineer of the Mexican Central Ry. He died in Davas, Switzerland, on Dec. 3, 1883, while still a comparatively young man, but 39 years old.

Henry R. Holbrook, of whom I have spoken above, afterwards had charge of the location of the St. Louis & San Francisco R. R. from Jerome to Springfield, Mo. In 1869 to 1870 he was employed in locating and had charge of constructing 70 miles of the Union Pacific R. R. from Kit Carson, Colo., westward. The following year he was Chief Engineer of the Denver & Boulder Valley R. R., and for a short time a locating engineer on the Denver & Rio Grande.

In 1872 he went to Mexico, where he was engaged in reconnoisance surveys for various roads. Two years later he returned to the States as Chief Engineer of the Pueblo & Salt Lake R. R.

*Consulting Engineer, Pomona, Cal.

From 1878 to 1880 he was Resident Engineer of the Atchison, Topeka & Santa Fe, and for the next two years Chief Engineer of the Western Division of the Atlantic & Pacific R. R. By 1883 he was back again in Mexico to examine prospective routes for railways.

From 1887 till 1890 he was again Chief Engineer of the Pueblo & Salt Lake R. R. After 1890 he devoted his time to irrigation and land work, making his home in Pueblo, Colo. He prospered financially, as well as professionally, for his estate at his death was estimated at $1,000,000. But Mr. Holbrook will be remembered, as was written of the great Samuel Johnson, by "the best portion of a good man's life, his little nameless, unmentioned acts of kindness and of love."

He was born in 1838, at Columbia, Conn., the second of seven children of Nathan K. Holbrook and Jane Porter, his wife. He was educated in the common schools, and at the age of 17 left home to make his own way in the world. The late J. G. Holland wrote: "We often hear it said of a man that he had great advantages. We have meant by this simply the advantages that wealth could buy—university training, travel high society, unlimited books, etc., etc. It is not often that we hear poverty spoken of as an advantage, yet we believe it to be demonstrably true that of all the advantages that can come to any young man, this is the greatest."

Epictetus said: "'The life of the dead,' says Cicero, 'rests in the memory of the living.'" Few of Mr. Holbrook's associates are left now among the living.

Notes on Design, Construction and Operation of High Tension Electric Transmission Lines.*

By C. D. GRAY,† M. Am. Inst. E. E.

It is the purpose of this paper to bring out some of the points that should be considered in designing, constructing and operating aerial high-tension transmission lines, voltages above 10,000 to be considered as high tension. There has been and still is too little attention paid to the proper engineering and construction of these important links, connecting as they do, power stations with substations and consumers located many miles from the source of power.

One large plant suitably located using larger units with a better load factor can produce and deliver power at a price to carry the additional investment in the transmission lines and substations and still make a profitable showing over the operation of several steam generating stations supplying the same district.

In many systems, a hydraulic station is operated in conjunction with steam stations, the steam plant taking the daily peaks, supplying the necessary power during shortage of water and floating on the system ready to take up the load in case service from the water power is interrupted, due to line or other troubles. Steam turbines are particularly well fitted to operate on the system in this way as they serve as synchronous condensers to increase the power factor and thus give better regulation and decrease the line losses. At the same time they are ready to pick up the load without interruption if the other source is suddenly cut off.

The distance to which power can be transmitted economically depends on the cost of fuel and labor, the railroad facilities of the district and the first cost of the complete power development, including water rights, real estate flooded by water storage, rights of way for the transmission lines,' cost of power-house, lines, etc. The present limit seems to be from 200 to 250 miles on the Pacific Coast. The longest one in the East is that from Niagara Falls to Syracuse, about 160 miles. These limits are being extended by the introduction of higher voltage apparatus so that to-day 150,000 volts is not considered beyond the bounds of reason, 110,000 being used on four or five systems now.

The possibility of building steam plants at the coal fields where culm or other cheap grades of fuel could be used, for transmitting power to neighboring cities. has been proposed and there is one company doing this at the present time in Pennsylvania, the Harwood Power Co., which distributes power at 30,000 volts.

Coming now to the transmission line, we will take up briefly some of the points that should be considered in design and location. The voltage and number of circuits are usually the first points to be decided. These depend more particularly on the amount of power to be transmitted and the allowable loss and the distance, but the character of the load in respect to power factor, load factor, desirability for securing continuous service and character of country over which the line is to run, are also points to be considered.

VOLTAGE.—In general, the voltage is determined from the allowable losses in the line with the most economical size of conductor. Kelvin's rule applies fairly well to this determination. This is that for a given voltage the annual cost of energy wasted or lost shall be equal to the interest on the investment. Usually each case has to be treated on its own merits. A so-called "rule of thumb" method is that the pressure in kilo-volts shall be equal to the distance in miles. In any case this problem usually resolves itself into a cut and try method for the first attempts in determining the size of the conductor, which can be carefully calculated later. The total voltage drop can be taken care of by taps on the step-down transformers.

A starting point for conductor size is usually No. 4 copper or No. 2 aluminum for the smallest size to be used on short spans, and No. 2 copper and No. 0 aluminum for longer spans on account of mechanical strength. This being the starting point, the voltage may then be determined to keep the loss within the limits desired. By loss is meant the actual C^2R or ohmic loss (and not the voltage drop). This is usually kept from 5 to 10% of the delivered power. When duplicate circuits are installed, it is satisfactory to allow this loss when both are in service. If one is out for a time the generating voltage can be raised sufficiently to keep the delivered voltage at its proper value.

NUMBER OF CIRCUITS.—The number of circuits to be installed depends on the amount of power to be transmitted and the continuity of service required. In general, if it is necessary to keep the initial cost of the development low, and the system to be supplied has another plant or a steam plant kept under steam with engines or turbines floating on the system, it may be the best engineering to install but one circuit. In many cases where the voltage allows, the poles or towers may be equipped for two circuits and but one installed at first until the demand for power increases sufficiently to warrant the cost of installing the second circuit, or the loss becomes too great on one circuit.

If the system to be supplied has no other plants operating on it, it is usually considered best to install two or more circuits either on one line of poles or towers or on separate lines on the same right of way, or in cases where the transmission is a very important one and the initial expense is not considered as vital as continuity of service, it is best to install a part of the circuits on an entirely separate right of way over a different section of country in order to avoid local storms. This method gives the best assurance against interruption but involves an additional first cost of construction and increases the cost of patrolling and repairs. Two single circuits, on different routes making a loop, are also good as they take the place of a double circuit.

In regard to the advisability of installing two circuits on one line of poles or towers, this is entirely feasible up to 35,000 volts on wood poles, and one can be repaired while the other is operated, care of course being taken to see that the dead wires are securely grounded before being touched. With steel towers, duplicate circuits of any reasonable voltage can be similarly repaired. This type of construction is cheaper than the installation of each circuit on its own poles or towers, but has the slight disadvantage that some causes of interruption will put both circuits out of service simultaneously, such as falling trees or large branches that will touch both circuits at the same time. Greater care must also be used in repair work on account of the proximity of the live circuit.

There is no advantage in single lines in respect to the usual causes of interruption, such as lightning, surges, mechanical breaks in wires, insulators, pins, poles or towers, caused by wind or ice strains on conductors and such as short circuits or grounds caused by conductors swinging together or into the supporting structures.

Another problem that arises is to determine the connection of the circuits, whether delta or star, and if star, whether to ground the neutral at the power-house and substations or not. Engineers differ in regard to this question. For voltages up to 45,000, it is probably better to operate delta in most cases and above that value to connect star with the neutral grounded, although some systems at higher pressures are operated delta, the Central Colorado Power Company, being an example.

The delta-connected circuit can be operated on two wires and if single-phase transformers are used, one of a bank of three can be taken out without appreciably disturbing the voltage relations, the only effect being that it reduces the capacity of the bank. The voltage between any wire and ground is greater with the delta system for a given voltage between wires than for the star-connected system. For example, on a 66,000-volt circuit the voltage between one wire and ground is only 38,000 volts when connected star, while with the delta connection it is 66,000.

The star circuit can be operated on two wires, provided there is a dead ground at both ends of the line, but the voltage on the phases is apt to be somewhat unbalanced, depending on the conditions of the grounds, their number and distance apart. Two transformers can also be used with the same disadvantage. The grounded-neutral star-connected system lends itself better to the use of the Nicholson and other similar methods of testing for broken insulators or grounds on the system.

SLEET AND WIND.—The size of conductor is dependent not only on the losses but also on the sleet and wind conditions, especially for steel-tower construction. The allowance to be made for these factors depends on the section of country traversed by the line and the factor of safety desired. The Weather Bureau records for several years past, from stations in the vicinity of the line, should be consulted and as much local information secured as possible regarding sleet and wind conditions. The telephone and telegraph companies often have some records available.

It is generally safe to use 8 lbs. wind pressure on the projected area of the wire, together with ½-in. radial thickness of sleet in sections where sleet forms. This wind pressure is equivalent to an actual velocity of about 56 miles per hour or an indicated velocity of 70 mi. per hr. calculated from the formula $P = 0.0025\ V^2$, in which P is the pressure in pounds per square foot and V is the actual velocity in miles per hour.

The amount of sleet to be considered is a much debated one, especially with aluminum wire. Some engineers say that sleet will not form on a live conductor and not at all on aluminum. The writer believes that it will form on aluminum, especially after the wire has been installed for some time so that the initial greasy coating has had time to wear off and the oxide has formed on the surface. While sleet is not apt to collect on a live wire with high voltage, still there is always danger of the wire becoming dead due to some interruption and then the sleet does form.

RECONNAISSANCE.—The voltage, size of conductor and type of connection are usually determined before the country is actually seen by the engineer and then it is necessary for him to visit the section of country and go over the proposed route or routes for the lines as carefully as possible with the best maps available, accompanied by someone who is familiar with the territory, preferably a civil engineer who has been engaged on the preliminary engineering, so that decisions can be made regarding the route, type of construction, whether wood or concrete poles with short spans or steel towers with long spans.

The route should be gone over on horseback, or with a team if it is near a highway, and notes made on a map or in a field book regarding timber, character of soil, condition of land in respect to cultivation, roughness of profile, kind of highways for transporting material, proximity to railroad stations and any other facts that might have a bearing on the cost of construction, cost of right-of-way or ease of patrolling and making repairs.

Two or three of the most desirable routes should be gone over in this way and a comparison made as to the advantages and disadvantages of each. The maps of the U. S. Geological Survey are a great help in this work. If it is impossible to visit the locality, they may even give a fairly good idea of the various routes if made up from recent surveys, but the older ones are sometimes misleading, especially in the location of highways, as often times these have been changed.

From the results of the above reconnaissance it may be decided whether the country would be best for poles or towers. If there is any question in this respect, the approximate cost of right-of-way, clearing, hauling material, digging holes, etc., must be found, also whether or not the locality is subject to wind, sleet or lightning storms of especial severity. All of these factors must be considered before deciding upon a definite route.

RIGHT-OF-WAY.—All of this preliminary reconnaissance work should be carried on as quietly as possible without exciting the attention of the land owners, whose prices for property invariably increase rapidly when the project is known. In many states power companies do not have the right of eminent domain so that it becomes necessary to purchase the right-of-way or easements. Consequently a good right-of-way man, who has had considerable experience in securing rights-of-way for railroad or transmission lines, should be secured and given considerable latitude in his dealings with the land owners. This man if possible should be acquainted locally so that he may know how best to approach the people.

The problem of securing reasonable prices for rights-of-way is much more difficult for a high-tension line than for a railroad, as there are no attendant advantages to the land owners unless they are broad-minded enough to realize that the general community will be benefited by cheap power which will benefit them indirectly. Such persons are, however, usually scarce. It is well, if possible, to give the right-of-way man two alternate routes to work on in case he encounters any especial difficulty in one route.

The right-of-way may be purchased in fee simple, in which case it may be fenced or not, depending upon circumstances. Usually the farmers are allowed to cultivate the land provided they do not injure or interfere with the line in any way. This is advisable as it keeps

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†J. G. White & Co., 43 Exchange Pl., New York City.

down grass and brush which might cause trouble from fires or require cutting periodically. The right to enter the right-of-way strip either by patrolmen or repair wagons should be reserved. It is best to have nothing stated in the deeds regarding cultivation but to allow it, so that in case the power company desires, it may fence off its property.

Often easements are obtained for setting poles or towers. These may be perpetual or limited by time, preferably the former. In this case the right to enter the property, patrol the line and repair it must be secured. If possible the center line should be defined across each property without the number and location of poles or other structures specified, as it often happens that additional ones may be desired later, which gives the owner an opportunity for cancelling the original contract and demanding exorbitant prices under the new agreement.

It is hoped that all the states will give power companies the right of eminent domain as transmission lines tend to husband natural resources and increase the prosperity of the districts which they serve and it is hoped, that by means of intelligent and temperate discussions of conservation, these rights will be secured to power companies in all localities.

The width of right-of-way to be secured depends on the number of pole lines and the cost of land, but should not be less than 100 ft. for any important line and should be entirely cleared of trees and brush and if the section is subject to forest fires, fire trenches should be plowed along its edges to help protect the structures from damage and prevent fires from crossing the right-of-way if possible. All trees outside this right-of-way strip that would reach the line in falling should also be cut. All timber and brush should be disposed of in some way or burned so that dead branches will not be picked up by the wind and blown across the circuits or furnish fuel for forest fires.

If easements are secured the clearing should be done in the same manner. In rough country it may be necessary to make wagon roads or paths so that the construction, patrolling and repairs may be done more easily.

After the right-of-way options have been secured for the entire line, with more or less flexibility as to route, a survey party should be put into the field and the center line of the right-of-way located. Care should be taken to make the line as straight as consistent, and where a change of direction has to be made, to make it on a curve so that the turn will come on several structures instead of one so that standard structures can be used. Topography should be taken for a strip about 1,000 ft. wide and all buildings, fences, highways, telephone, telegraph and other pole lines definitely located and notes regarding cultivation and trees made. The plan of this strip should be plotted on a scale of 1 in. equals 400 ft., together with a profile of the center line on a scale of 1 in. equals 20 ft. vertical scale. If it is to be a steel tower line with long spans, another profile should be made with a horizontal scale of 1 in. equals 80 ft., and a vertical scale of 1 in. equals 20 ft. This profile should show the height of other lines crossed and the location of highways and property lines.

CONSTRUCTION FEATURES.—The type of construction to be adopted depends on the importance of the system, number of circuits needed, first cost of construction and the cost of maintenance and repairs. The cheapest in regard to first cost for a single circuit is of course a wood-pole line, the poles being spaced as far apart as possible consistent with safety. This depends on the size of conductor and the wind and sleet conditions to be encountered. In the writer's opinion 200 ft. is the maximum span allowable and from 125 ft. to 150 ft. is better for average conditions with moderate sized conductors. This refers to a single three-phase circuit with a grounded wire for lightning protection.

The stresses in the wire and poles should allow for a factor of safety of at least two under maximum wind, temperature and sleet conditions, the stress in the wires and their supports being found by the use of the formula

$$S = \frac{WL^2}{8d},$$

in which S equals stress in pounds, W equals the equivalent weight of 1 ft. of conductor in pounds, L equals the length of span in feet and d equals the deflection or sag of conductor in feet, W is the resultant weight of conductor including ice and the wind pressure exerted on the conductor, and ice, taken at right angles. This gives the stress on the conductor and on the insulator support for pin-type insulators. If suspension-type insulators are used, the stress on the insulator support is less than on the wire by about 15%, due to the fact that if the wire breaks, the insulator moves from its vertical position and takes the direction of the wire, thus increasing the deflection and decreasing the stress. The effects of temperature and elasticity can be neglected on short spans.

The kinds of timber principally used in wood-pole construction are chestnut, cedar, cypress or juniper, red wood and pine, the latter being used principally when impregnated or treated with some wood preservative. All of these woods will rot more or less at the ground line and may be protected to prevent this action. As the price of poles goes up due to the scarcity of timber, it becomes more necessary to prolong their life or make use of concrete or steel construction.

The methods of treating are, (1) impregnating the entire pole by the vacuum process, using creosote, zinc chloride or other wood preservative, (2) the open-tank method of boiling the butt in one of the same preservatives for 7 or 8 ft., and (3) the brush treatment of the entire butt or only the section around the ground line extending 2 ft. below and 1 ft. above the ground. In the writer's opinion the treatment of the entire pole is not justified and possibly the open-tank method may also be too expensive at the present time. It is then a question of using the brush treatment, which may increase the life from 25 to 50%.

WOOD POLES VS. STEEL TOWERS.—Among the advantages claimed for wood construction are, cheapness in first cost, ease of construction (as no special workmen or apparatus are needed) the advantage of having the insulation of the pole between the conductor and the ground (which is of doubtful value on high potentials), and the possibility of having a cross-arm or pole top burn off from an arc caused by a defective insulator without interrupting the service. A single line of poles of this kind may in some instances be installed at the side of highways, electric or steam railways where permitted, thus saving the cost of right-of-way and rendering patrolling easy.

Some engineers and operating men prefer two wood-pole lines, each carrying a single circuit, to a double-circuit wood line, even though their first cost and maintenance are much greater, believing that two circuits on separate structures even on the same right-of-way are not so liable to interruption from a common cause, and also that repairs can be made on one safely while the other is alive. Some prefer two wooden-pole lines to a double-circuit steel-tower line for the same reasons, even with the greater cost of the pole lines and the much greater cost of maintenance.

It has always seemed to the writer, however, that the steel construction is the better on account of the fewer insulators per mile and the lower cost of construction and maintenance. The life of the best wood construction is not over 12 to 15 years, while steel towers should be good for an almost indefinite period, provided they are properly maintained.

No data is available regarding the life of steel towers as they have not been used long enough to determine their life, especially if galvanized. Galvanizing should be good for 10 or 12 years and then by painting every two or three years with some good preservative paint, such towers ought to last 40 to 50 years or even longer.

The writer has a section of 3½ × 3½ × ¼-in. plain angle iron that was once one leg of a wind-mill tower which had been installed 19 years and which is not corroded to any extent except at the ground line where it was practically eaten away. If this had been properly protected for a distance of 18 ins. at this point, the tower would still be standing, for the rest of the angle was practically as good as when installed.

Single-circuit pole construction does not lend itself well for supporting a grounded arrester wire over the power conductors, as some sort of an iron support must be used. On a double-circuit, wood-pole line this wire can be carried on the top of the pole, preferably installed on a pole-top pin and insulator, the insulator merely being used to furnish a smooth support for the wire and to which it can be tied. Among the other disadvantages of wooden construction are the increasing cost of poles in all sections of the country, the decreasing factor of safety of the line with the age of the poles and the difficulty of transporting poles in mountainous regions.

For wood construction the cross-arms should be of extra size. Iron pins with separable thimbles for cementing into the insulators should be used, and in general the construction should be the best in all respects.

Concrete poles are coming into use, replacing wood, but they have been of such recent construction that no conclusion can be made regarding their durability. They will doubtless be used more and more as wood increases in price and more data is available regarding their characteristics. The practical disadvantages of concrete poles are their high first cost in manufacturing, hauling and erection, and the difficulty of obtaining uniform product. There is also the problem of fastening the cross-arms to the poles so that the fastening will be substantial and not corrode.

Wood and concrete poles lend themselves best to the use of pin-type insulators which may be used with reasonable safety up to 66,000 volts, beyond which voltage, suspension-type insulators must be used. The latter require greater lengths of supporting cross-arms on account of the tendency of the insulators to swing as pendulums about their supports which increases the strain on the cross-arm and the torsional effect on the pole.

STEEL TOWERS.—We will not consider tubular or small built up latticed steel poles, the cost of which is too high to consider for high-tension line work. In some cases where the lines are run along railroad rights-of-way such as the New York Central, New Haven or Long Island railroads where the voltage is restricted to from 11,000 to 22,000 volts, they may be used but their cost is very high.

Steel tower, long-span line construction is the best in nearly all cases where private right-of-way or easements can be secured, if it is possible to use high voltage so that the conductor is kept within a reasonable size. These towers should be made up of small structural shapes such as angles and channels. Some engineers and manufacturers of towers make use of rods, flats and pipes, but it is best to use only angles and channels bolted together in the field. Certain members, however, such as cross-arms for holding the insulator supports and the grounded wire support, may be made of two channels latticed together and riveted in the shop so that the whole member can be galvanized. The other members should be galvanized after the holes are punched, galvanized or sherardized bolts being used in all cases.

In designing towers of this kind it should be borne in mind that they cannot be designed by ordinary structural or bridge formulas, as the factor of safety and deflection of the different members are so different. A factor of two or three is used and deflections that would not be safe in other types of construction, so that the design is more or less the result of experience and of tests on sample towers built up and actually tested with the different loads and combinations of loads that may be imposed in actual service. In making such tests, if the material for the test tower has not been galvanized, an allowance should be made as the strength may be decreased from 15 to 20% by galvanizing, because the shapes are so thin, ⅛-in., 3/16-in. and ¼-in. material being commonly used.

Towers should be designed for the standard height and strength desired and then extensions of 10, 20 or 30 ft. should be designed to fasten to the bottom of the standard towers to make higher ones. These extensions should be arranged to bolt to the corner legs of the towers without any drilling or fitting in the field. All towers should be designed to take the same wire stress as the standard towers, in fact the stress in the wires and the clearance to ground should be kept constant and the sag and span varied. In this type of construction it is interesting to note that the cost of line per mile is practically the same for different heights of towers and lengths of span with the same size conductor and stress on it. This statement, of course, applies within certain limits and could not be used in all cases, but it works out, with stress in wire and supports of about 2,000 lbs. with a 25-ft. clearance to the ground at the center of the span, that 50-ft. towers, spaced as far apart as possible to give a factor of safety of about 2 in the minimum size of conductor used, give about the most economical and reasonable height and strength of towers. These will give spans of from 575 ft. for No. 1 copper to 500 ft. for No. 0000 copper. When the stress exceeds 2,000 lbs. in the wire, it is necessary to increase the thickness of the material in the towers which increases their cost and, although allowing higher towers and longer spans, does not decrease the cost per mile.

Double-circuit towers, of the ordinary construction, support six power conductors, one grounded wire and two telephone wires. The towers should withstand torsional stresses due to one circuit being broken one side of the tower or both circuits being broken on the same side, that is each tower should be a dead-end tower. Under these tests the steel should not be stressed beyond its elastic limit and no permanent deflection of any member take place. In some cases it has been thought best to install dead-end towers at intervals of say ½ mile, the intermediate towers being of lighter construction, so that they would probably fall if the wires were broken. It has always seemed to the writer that the slight additional cost of having each tower a dead-end or anchor tower is justified on account of the greater factor of safety in the line.

When shipped, the towers should be packed in bundles of about 200 lbs. unless some special difficulty prevails. All pieces should be plainly marked and the bundles arranged so that a complete tower can be delivered at the site of erection without breaking bundles. Bolts, washers and other small parts should be shipped in boxes or kegs packed individually for each tower.

It is usual to have the tower manufacturer supply the pins for pin-type insulators and fastenings for the ground wire. The power-wire pins should have separable thimbles that can be cemented into the insulators at the insulator factory. The telephone insulators can best be cemented direct to the pins. The grounded-wire support is usually a mechanical clamp or smooth-casting shaped like a cable-top insulator to which the wire can be tied.

The spacing and location of wires differs for different voltages but a safe rule to follow is that on long spans nothing less than 60 ins. be used up to 60,000 volts and this increased 1 in. for each 1,000 volts over 60,000. With suspension-type insulators care should also be taken to see that when the insulators swing with the wind they do not come too near the supporting structure. It is usual to assume them swinging to an angle of 45° from the vertical and in this position the wire

should not be nearer the supports than 20 ins. for 60,000 volts, plus ½-in. for each 1,000 volts over 60,000. It often happens that light wires, especially aluminum, will swing beyond 45°. In fact, the writer has seen wires blown out nearly horizontal, in which case the clearance mentioned above should be maintained with the horizontal position of the wire.

The telephone circuit, if one is to be installed on the towers, should be located below the power wires and as far from them as consistent with the ground clearance. Power wires should be at least 22 or 23 ft. above the ground at the lowest part of the span and the telephone wires might be 6 ft. lower. This minimum clearance depends on local conditions.

ANCHORS.—The anchors for the towers are always separate from the corner members and arranged to bolt to them, so that they can be set before the towers are erected. The best form of anchor consists of an angle about 6 ft. long with a cross consisting of two pieces of the same material about 2 ft. long bolted to it. This type will usually develop enough holding down power to satisfy the requirements in all kinds of ordinary soil. In soft ground special footings may be needed, depending on the local conditions, and if stones are available, it is well to place some large flat ones on the bottom pieces before tamping the earth in any kind of soil. When solid rock is encountered, the tower legs can be held down by foundation bolts grouted into holes about 3 ft. deep drilled into the rock.

The anchors need protection only at the ground line and a good plan is to install a sleeve of grout about 9 ins. in diameter around them extending 6 ins. above and 24 ins. below the ground line, the top being carefully roofed to shed water. Some lines have special concrete anchors to which the towers are fastened by holding down bolts, others have the entire anchor encased in concrete and some have no protection whatever, but the writer considers that the sleeve of grout will satisfy all requirements.

SPECIAL WORK.—In any kind of construction there may be cases in which special designs are necessary, such as crossings over telephone, telegraph and other circuits, over railroads and streams or for long spans. The subject of crossings over railroad, telephone and telegraph lines is now being discussed by joint committees representing the National Electric Light, the American Railway Engineering and Maintenance of Way and the American Electric Railway Associations, and standard specifications are being worked out which it is hoped may be adopted. [See report of the annual convention of the National Electric Light Association, Eng. News, June 8, 1911.—Ed.]

Stream crossings, or especially long spans, are usually best worked out for each individual case. The chief difficulty in their design, up to quite recent date, has been of obtaining insulators of sufficient strength and insulating qualities to hold the conductors. Various methods have been used, one in which several pin-type insulators are mounted in series to the top of which the cables can be fastened. With the introduction of suspension-type insulators the problem was simplified somewhat, as several sets of these insulators could be used in multiple, but the insulator manufacturers are now prepared to make special units that will have sufficient strength and insulation in one piece up to 60,000 volts.

For long spans, special cable is usually needed of high tensile strength, such as crucible or plow steel or one of composite material consisting of a steel core with copper coating, which is good where the utmost tensile strength is not required and some conductivity is needed. In this long-span work, the elasticity or spring action of the cable, as well as its temperature coefficient become quite important factors, especially if a certain clearance must be maintained, the first being the most important. In such cases it is best to make a series of tests on the material to be used to determine its elongation under various amounts of stress. With this data the actual length of cable in the span can be closely calculated and the cable correctly measured and cut to length. It is also best to install turnbuckles in the cables to adjust them so that they will hang parallel and allow for proper adjustment in length if not measured and cut correctly.

For long spans with one, two and three circuits, it is best to arrange the wires in a horizontal row and to omit the grounded wire. It has seemed advisable in some cases to install an extra conductor that can be connected in place of one of the others in case of trouble, but this seems hardly necessary if the proper factors of safety are used in the design of the structures and cables.

FIELD CONSTRUCTION.—Coming now to the construction of the line, there are no especial features in wood-pole line construction that are novel and the location of the line on private right of way, some of which might possibly be rough, precludes the use of derricks or other apparatus for raising the poles so that the method of raising them by hand with pike poles is ordinarily used. The cross arms, ground wire supports and insulator pins are usually put on before the poles are raised and the insulators installed later just previous to the stringing of the wire, to prevent breakage and loss by theft or otherwise. Often times for voltages of 35,000 or less, the insulators are installed when the poles are on the ground.

The wires are usually strung by hand or with a team. If the ground is rough or aluminum wire is used, which is easily abraded by dragging on the ground, it is run through snatch blocks attached to the poles or towers so that it does not touch the ground. Sometimes rollers are used which may be fastened to some parts of the cross arms or towers over which the wire can be hauled. Smaller wires can be hauled over wooden cross arms without injury to either, but the larger sizes are apt to injure the cross arms. It is not wise to haul wires of any size over steel structures. After the wire has been hauled out in convenient lengths, depending on its size, it can be spliced, sagged and tied to the insulators.

Care must be taken in the interval between stringing the wire and the turning on of current to prevent theft of wire. In fact it is often advisable, if current is available at one end of the line, to start work on this end and at times when the workmen are not employed, to make the wire alive so that anyone trying to steal the conductors will find them "hot."

For concrete-pole construction, the same conditions prevail except that it is impossible to pike the pole into place and some sort of derrick or gin pole must be used.

In the construction of steel-tower lines, after the clearing has been done, the station points for the towers are located from the office plot and if satisfactory in respect to character of the ground at that particular spot, the center is located and stakes driven locating it and the corners of the tower. If it is found that the office location of the tower places it on a spot unsuitable on account of the presence of boulders or local roughness requiring considtrable grading to drain all four corners, it may be relocated and the adjacent tower locations changed slightly to compensate for this change.

It is advisable to locate towers near highways and also near telegraph and other pole line crossings so that there is a maximum clearance at these points. It is also desirable to locate them near property lines so that in case there is any trouble with one of the property owners, the tower can be taken from his property and installed on that adjacent.

In the construction of the line, the holes are usually dug by one gang and the anchors set and tamped in by another. The anchors must be set correctly by means of a steel template so that they will be properly spaced and have the proper inclination to take the tower legs. They must also be absolutely level so that the tower will be perpendicular when erected. If the sleeve type of protection at the ground line is used, a sleeve of thin sheet iron is installed when the hole is filled with earth and tamped, within about 24 ins. of the ground line. The sleeve is then filled with grout and the rest of the hole is filled with earth and tamped. The ground usually settles around each leg so that it is necessary to fill the hole again after several weeks when the ground has thoroughly settled.

The towers are assembled complete on the ground by one gang and erected by another gang, the erection usually being done by the use of a gin pole or derrick.* In some cases two of the tower legs are fastened to their anchors by means of temporary bolts to hold the tower in position while being raised. In other cases a stiffening frame is fastened to all four legs and this frame fastened to the ground on one side during the raising process. The erecting has to be done very carefully so as not to drop or strain the tower, which is easily injured.

The main insulators are usually installed just before the wire is strung. After the wires are strung, as described before, they are ready to be sagged and tied. One of the bottom wires is ordinarily sagged by the use of paint spots on each tower, these being at the elevation of the lowest part of the wire catenary, being located from the profile of the line which has the towers and catenary lines drawn on it. A man climbs one tower until his eyes are on a level with the spot on this tower, sights at the spot on the adjacent tower and has the wire raised or lowered until its lowest point is at this level. The wire is then clamped fast and tied to the insulator.

All the wires are usually installed at the same time and the telephone wires connected up for use with portable telephone sets, so that the construction gangs can keep in touch with each other and the construction office.

The methods of fastening the wires to pin-type insulators consist of different ties or mechanical clamps. For ties, the double or so-called Mershon tie is good, especially for aluminum wire where it is necessary to protect the wire, for some distance beyond the insulator head, against arcs from the upper petticoat. This tie consists of two ties, one on each side of the insulator. One end of the tie wire is started at the head of the insulator and served around the main conductor outward for 3 or 4 ins., the wire is then carried around the tie wire groove of the insulator and the end again served outward from the other serving until the main conductor is covered for 3 or 4 ins. beyond the edge of the upper petticoat of the insulator. Another similar tie is used on the other side of the insulator. It is usual to protect the conductor in the wire groove of the insulator with a sleeve of the same material as the conductor. This sleeve extends just beyond the head of the insulator. It is usually of U section with the ends swaged out, so that it will not cut the conductor, and when it is installed it is hammered down on the top so that it will be held in place.

Mechanical clamps are also used, but in the writer's opinion, are not as good as the above tie as they tend to cut and abrade the conductor and do not protect it from arcs. The above protecting sleeve and method of tie is especially desirable when aluminum wire is used which is more easily abraded and effected by arcs than copper. For use with suspension insulators, various types of mechanical clamps are used, designed so as not to injure the wire.

The problem of obtaining satisfactory methods of splicing the conductors on long span work is a difficult one as the strength of the conductor is limited by the strength of the joint. The cable itself may have only 75% to 90% of the tensile strength of the individual strands and the joint only 85% or 90% of the strength of the cable, so that the combined efficiency of the joint referred back to the tensile tests on individual strands may be from 65% to 85%. In some rare cases, however, an efficiency of from 90% to 92% has been obtained.

The joints that seem best adapted to this work are the twist sleeve joints made longer than usual so that three or more complete twists of the conductor can be made. Care should be taken to see that no joints occur in especially long spans where the cable is stressed more than usual.

After the wire has been strung and tied it is necessary to make very careful inspection of the line to detect poor ties, broken insulators, etc. A careful, reliable man should climb every tower and inspect each insulator and tie carefully. Ringing the insulator with a piece of metal will usually detect cracked petticoats.

Great care must also be used when the current is first turned on the circuit to see that no workmen are on the line. Low voltage should be impressed at first and gradually raised from 15 to 25% above normal or whatever excess pressure can be obtained without injuring the apparatus supplying it. This should be done on open circuit at the receiving end and the circuit breakers should be set as low as possible during this time so that they will trip out easily in case of trouble. This excess pressure should be kept on for several hours and after this, normal pressure for several days if possible before any power is taken over the line for commercial purposes.

During this preliminary period the patrolmen should be started on their duties and the station operators should stand their regular watches. If the substations are completed, the current can be switched into them and the transformers operated on no load, provided they have been dried out and are ready for voltage. In some cases the line has to be run on very low voltage for drying out the transformers in the substations on short circuit heat runs if no current is available there from other sources.

OPERATION.—The proper operation of the line is very important, as its reliability in regard to interruptions and service depends on the ease and quickness with which repairs can be made when accidents happen. No line can be constructed that will not have shutdowns occasionally and the best line is therefore the one that has the least number and for the shortest time.

The causes for shut down are many; defective insulators being the principal one. These may be either broken mechanically or punctured electrically by surges and lightning strokes. Large pin-type insulators seem to have a great attraction as targets for shot and stone. People also like to throw pieces of wire over the circuits to see the fireworks caused by an arc. These things are hard to prevent but if a few offenders are caught in the act, arrested and taken to court, it usually lessens the trouble. In many cases if the public is properly instructed through the newspapers or otherwise, that the operation of factories, electric lighting systems, etc., depend on the transmission lines and are told that they are causing other people hardships when they do such things, it often happens that they will see the reasonableness of the request and will not cause any more trouble.

Other causes of interruption are the arcing over of insulators or wall bushings under snow or rain conditions, together with an excessive rise of potential at the same time. This can be lessened by using insulators having a large factor of safety, 3 being usually sufficient. Several different schemes have been proposed to discharge the line temporarily before the power arc has an opportunity for puncturing or destroying the insulator when excessive potential arises and causes spillovers. Experiments are being made with "phase protectors" to ground one wire when this action takes place without interrupting the service. One large power company is equipping all its insulators with so-called arcing rings, which consist of a grounded ring surrounding the lower

[*See an article on the erection of steel towers for the Ontario Hydroelectric Commission, Engineering News, April 27, 1911.—Ed.]

petticoats of its pin-type insulators at some distance from the petticoat, to which any power arc will jump from the head of the insulator, thus saving the insulator from the effects of the power arc playing over its surface.

Large birds often short circuit or ground the line by flying into it or by resting on one of the lower wires and getting their heads onto the upper wire.

Salt fogs together with dirty insulators formerly caused trouble but with the modern design of insulators using greater factors of safety, this cause is practically eliminated.

Lines located near cement works or other factories giving out fine dust need very careful attention and frequent cleaning of the insulators.

The charring or oxidizing action on wood pins is also a frequent cause of trouble and, in the writer's opinion, only iron pins should be used on high-tension lines.

Occasionally wires break due to defects in material, but such accidents are rare, as the factor of safety should take care of most cases of this kind. Careful inspection during construction also tends to prevent this trouble. The failure of the supporting structures is also a rare occurrence if they have been properly designed and if their footings have been properly set.

Careful patrolling has much to do in lessening mechanical troubles on the line. Important lines should be gone over every day and others not so important twice a week, although some sections of the line particularly subject to troubles should be patrolled more often.

Supplies for repair work should be located at about two mile intervals along the line so that they can be reached easily and carried to the break in a short time. Each patrolman should carry a portable telephone set, some few tools including a "come-along" clamp, one or two wire splices, two or three tie wires and a grounding chain for grounding the line when he is working on it.

Small houses or booths should be placed at intervals with stationary telephones installed in them. They should also contain repair supplies and in cold climates, a small oil stove and some canned goods, coffee, tea, etc., for the convenience of the patrolmen. At junction points, or other special switching towers, it is advisable also to provide sleeping quarters for one of the patrolmen so that he will be available at night to operate the switches, which are usually of the knife-blade type. Telephones should also be installed in all patrolmen's homes so that they can be reached at any time.

The circuits should be sectionalized at least every ten miles by disconnecting switches, and at all branches, the main circuit should be sectionalized and switches installed in the branch line. Made-up jumpers should also be kept at these points so that the good wires of a section can be used by connecting them to the similar wires of the other circuit, provided it will take several hours to repair any break.

At important junction points, oil switches instead of disconnecting switches should be installed on the branches so that the circuits may be switched under load. These should preferably be made automatic so that any trouble on the branch will not interrupt the main line. Such switches may now be obtained suitable for installation out of doors.

Another problem is that of cutting out one of two circuits operating in parallel at both ends, leaving the other in service. This can be done by means of reverse current or differential relays if there is a source of power at both ends to keep the voltage up, but when the receiving end has no generating capacity the problem is more difficult. This is being worked out, however, and it is hoped that a solution may be found in the near future. A successful apparatus of this kind would greatly lessen interruptions to service on the majority of transmission lines or other systems where two or more circuits or feeders are being operated in parallel.

One of the greatest adjuncts to successful operation is a reliable telephone system. It is often advisable to have the telephone system also fitted for operation with telegraph instruments so that, in case the telephone instruments are out of doors or one wire is grounded, signals can still be sent over the good wire and the ground.

All instructions for operating the system should come from a head dispatcher who would be available at all times for issuing orders for the regular routine and in cases of trouble. This obviates all chances of confusion in switching and in getting the line back into service after an interruption.

COSTS.—The costs of construction vary so widely, due to local conditions, transportation, cost of materials and labor, locality, etc., that the writer hesitates giving anything but a few comparative costs, based on average conditions. However, a few costs of this kind may be interesting and in the table below is given the costs per mile of several different types of construction for a three-phase, 60,000-volt, 60-cycle circuit with No. 1 copper wire and suspension insulators, using four 10-in. discs, together with a suitable grounded conductor carried above the circuit. These figures do not include the cost of right-of-way, surveys, engineering or contractors fees.

One single-circuit	wood pole line	$2,550	per mile of route
Two " "	" " "	5,100	" " " "
One " "	steel tower "	2,950	" " " "
Two " "	" " "	5,900	" " " "
One double-circuit	" " "	4,600	" " " "
One " "	" " " (with one circuit installed)	3,700	" " " "

The above estimated costs are based on the use of 40-ft. 8-in.-top chestnut poles spaced 175 ft. apart, the grounded wire consisting of No. 8 copper-clad wire with the main wires supported on steel cross arms and the grounded wire on the top of the pole. The single-circuit steel towers have bases about 14 ft. square and the lower wires 50 ft. from the ground spaced 500 ft. apart with No. 4 copper-clad grounded wire. The double-circuit steel towers have the same characteristics as the single-circuit.

From the above figures, may be noted the slight increase in cost of a single circuit steel tower line over a wood pole line. Also the saving in cost of a double-circuit steel-tower line over two single-circuit, wood-pole lines or steel-tower lines. In the writer's opinion, the double-circuit, steel-tower line is the one to install in most cases where two circuits are needed, unless the system is a very important one and the initial expense of two lines on separate routes is justified in order to secure continuous service.

A Large High-Pressure Blower of the Sirocco Type.*

The accompanying illustration shows a centrifugal blower designed to deliver about 5,700 cu. ft. of air per minute at a pressure of 22 ozs. per sq. in. The wheel is 82 ins. in diameter and is directly connected, through a flexible coupling, to a 50-HP. direct-current motor running at 950 r. p. m. Thus the blower wheel has a peripheral speed of about 20,400 ft. per min.

This blower has been installed recently at the works of the Packard Motor Car Co., Detroit, Mich., to furnish air for blowing scale from deep dies in the drop-forging department. The

High-Pressure Sirocco Blower for Blowing Scale from Deep Dies.

air is directed into the dies through nozzles mounted beside the anvil blocks of the drop hammers. The pressure of 22 to 24 ozs., which is about twice that ordinarily considered sufficient for this sort of work, is made necessary by the large number of deep-cut dies used. We are informed that this blower has been guaranteed to effect a saving in power and maintenance cost over an equivalent reciprocating air-compressor installation, in addition to the saving of about 50% in first cost. Blowers of this type can be used also for furnishing blast to oil furnaces and for forge and cupola service.

The Preservation of Iron in Concrete is again attested in the demolition of an old gasometer in Hamburg, Germany, as reported by "Fer et Acier," of Brussels. This structure was built about 1852 and when taken down 48 years later, the iron anchor bolts which had been completed encased in a cement concrete were found to be as fresh and bright as new iron, with no traces whatsoever of rust.

*From information furnished by the American Blower Co., of Detroit, Mich.

The Steam Auxiliary Plant of the Utah Light & Railway Transmission Systems.*

A steam auxiliary plant has recently been put into service by the Utah Light & Ry. Co., which supplies practically all the electric service of Salt Lake City. This company has hydro-electric generating stations and transmission lines from the mountain regions nearby, but increase of business and the limited capacities of the available water powers have led to the construction of a steam-driven auxiliary station. The presence of coal measures in the Wasatch Mts., within 50 miles of Salt Lake City, led to the investigation of the best site for this auxiliary plant. At this point Westinghouse, Church, Kerr & Co., of New York City, were retained as consulting engineers. The advisability of producer-gas and steam plants and location at the mine was studied but a report was made in favor of a steam station adjacent to Salt Lake City and preferably on the Jordan River. In the following year, 1910, this firm was retained as designers and constructors of such station.

The following conditions governed the design of this station: (1) operation discontinuous at first and as a relay to the hydro-electric system; (2) an ample supply of condensing water, unsuitable, however, for boiler feed; (3) feed water purchased at relatively low cost; (4) coal, of 11,700 B.T.U. per lb., to be brought from mines already developed in Wyoming; (5) power-station site property owned by the company, and having railroad connections.

The first consideration implied a very low load factor (ratio of average to maximum output), which demanded economy in first cost. Accordingly, the plant was laid out so as to minimize the volume per unit of generating capacity. The cubic contents of the building, including switchboard room, is 56 cu. ft. per KW. maximum continuous capacity.

The station is designed on the unit system, each unit arranged so as to be operated alone or in parallel with other sections. Only one unit has been built. The boiler room contains six 600-HP. water-tube boilers and is of the same length as the turbine room. The boilers are equipped with mechanical stokers, but are operated under natural draft. The steam pressure is 200 lbs. with 125° superheat. There is one main generating unit with a maximum rating of 10,000 KVA. (for a temperature rise of 50° C.). The turbine is a Westinghouse-Parsons type running at 1,800 r.p.m. The generator supplies three-phase, 60-cycle current at 4,400 volts. The condenser is a "mixing" type (modified jet), known as the Le Blanc (described in Eng. News, Aug. 19, 1909). This condenser type has shown a vacuum of ½ to 1 in. better than the surface type under the same conditions, and the greater efficiency and reduced cost of maintenance more than offset the increased cost of feed water over a surface type. The air and circulating pumps on the condenser are driven by a small steam turbine. The switchboard apparatus is contained in cellular compartments of solid concrete. Future needs for greater capacity will be met by adding to this first unit one or more similar units enclosed in a building of the same size and type.

The building itself is of brick with concrete floors and roof. The boiler room has an overhead coal bunker of skeleton steel construction carrying the greater part of the load on columns. The turbine room has no steel framing other than that needed for the roof trusses, floor beams and crane rails. No money was spent on architectural effects, but the resultant design is considered well proportioned and dignified. For the foundations of the station, 36-ft. Oregon-fir piles were driven 2½ to 3 ft. between centers and overlaid with 3 ft. of concrete. The condenser intake overflow flumes, where within the building, are formed in this foundation cap. By means of a system of skylights placed just below the level of the coal bunker, the firing alley between boilers is provided with good daylight illumination.

*From information supplied by Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City.

Commercial relationship with the mining company rendered it unnecessary to provide coal storage. The problem was then of transferring the coal from railroad cars to stoker hoppers. The cars dump into a track hopper from which the coal is carried by an inclined bucket elevator to the top of the boiler house at one end. Here it discharges onto a horizontal belt conveyor and is distributed along the bunker over the boilers. The ashes are dumped from the ash-pits into side dump cars, which run on an industrial track in the boiler-room basement. From this level they are elevated by a platform lift to the ground level and are dumped on adjacent land.

Active construction of the station was started on Aug. 19, 1910, with the arrival of the first carload of piles. By the middle of October the piles were all in and the concrete wall enclosing the basement was well under way. By Nov. 10 the walls of the building were nearly finished and the stack well under way. Steam was raised in the boilers on Feb. 6, 1911, and the turbine was turned over on Feb. 15. The station was reported ready for commercial load March 22. The entire work of design and construction was executed by Westinghouse, Church, Kerr & Co., under the direction of the railway company, through Mr. O. A. Honnold, its Electrical Engineer.

A University Course With Degrees in Public Health, University of Michigan.

The University of Michigan has established two new courses in public health work both leading to degrees, one of Master of Science in Public Health and the other, Doctor of Public Health. The following official announcement explains the nature of the new courses:

COURSE I. A one-year course leading to the degree of Master of Science in Public Health. Candidates must possess the degrees of B.S or A.B., and M.D. The course of instruction covers one academic year, beginning with the opening of the University in the fall, and continuing until the following June. Work in the Summer School following the granting of the degree of M.D. can be credited on this course. At the close of the course an examination, both theoretical and practical, will be held, and a diploma of M.S. in Public Health will be given to all who successfully pass the examinations and show fitness for work in public health. In addition to the taking of the prescribed courses and the successful passing of these courses the candidate shall carry out a piece of original investigation of sufficient value, and shall present a thesis on the same, and successfully defend this thesis. The moral character of the applicants for the degree must be shown to be above question.

All candidates for the above degrees are subject to the rules and regulations of the University governing regular students.

The yearly fee is the same as for matriculated students in the Department of Medicine and Surgery.

SCHEDULE.

First Semester.

Advanced Bacteriology & Parasitology	10 hours weekly
Practical Hygiene (Meat, Milk & Water)	5 hours weekly
Physical Education	5 hours weekly
Sanitary Engineering (Plumbing, draining)	2 hours weekly
Building Sanitation	1 hour weekly
Hydraulic Work (Water supplies)	2 hours weekly
Autopsy Technique	2 hours weekly
Special Pathology of Infectious Diseases	5 hours weekly
Social and Vital Statistics	1 hour weekly
Sanitary Legislation	2 hours weekly

Second Semester.

Practical Hygiene (Foods, Clothing, Personal Hygiene, Prophylaxis, Quarantine, Isolation, Disinfection, Disposal of Dead, etc.)	10 hours weekly
Physical Education (Theory and Application of Physical Training, Practical Anthropometry)	5 hours weekly
Sanitary Engineering (Garbage and Waste Disposal)	10 hours weekly
Sewage	
Pathology of Occupational Diseases	1 hour weekly
Serum and Vaccine Therapy	5 hours weekly

The following departments are represented in the above schedule:

Medical:—Hygiene, Bacteriology and Pathology.

Engineering:—Hydraulics and Sanitary Engineering, Architecture.

Law:—Sanitary Legislation.

Literary:—Vital Statistics and Physical Training.

COURSE II. Course leading to the degree of Doctor of Public Health. Candidates must possess the degree of A.B. or B.S., in addition to that of M.D., and must pursue a course of two years after the degree of M.D. has been received. The first year's course is identical with that prescribed for the degree of Certified Sanitarian. The second year's work must be spent in research work in one or more of these subjects, with the presentation of a thesis containing original work of sufficient merit, which must be passed upon by and defended before all the members of the faculty concerned in the giving of the courses. The final examination will cover the branch or branches in which the thesis is presented. The examination for the first year's work can be held at the end of the first year. Fees the same for each year as for Course I. A portion of the prescribed work may be taken elsewhere, but the right to do this must be left with the faculty giving these courses.

LEGISLATION COMPELLING ELECTRIFICATION of railway terminals in Boston is strongly opposed by the New York, New Haven & Hartford R. R. Co. In a circular letter to members of the Massachusetts legislature it says:

Except where use of tunnels is rendered less dangerous by use of electricity, there has been no compulsory electrification of railroads. All the electrification of the New Haven has been without compulsory legislation. The New Haven has repeatedly stated its desire and willingness to electrify. This year it proposes to electrify from Readville on the Boston & Providence and to Beverly on the Boston & Maine.

Electrification of short distances, say ten miles, has never been found at all economical, and a compulsory electrification within a 10-mile limit will be unusually uneconomical.

Money required for electrification must be raised by the issue of new securities, and unless the money for electrification is wisely and economically expended, there will be placed upon railroad transportation a very serious charge which can only be met by increased freight and passenger rates. The best business interests of New England require these rates to be kept as low as possible, consistent with safety.

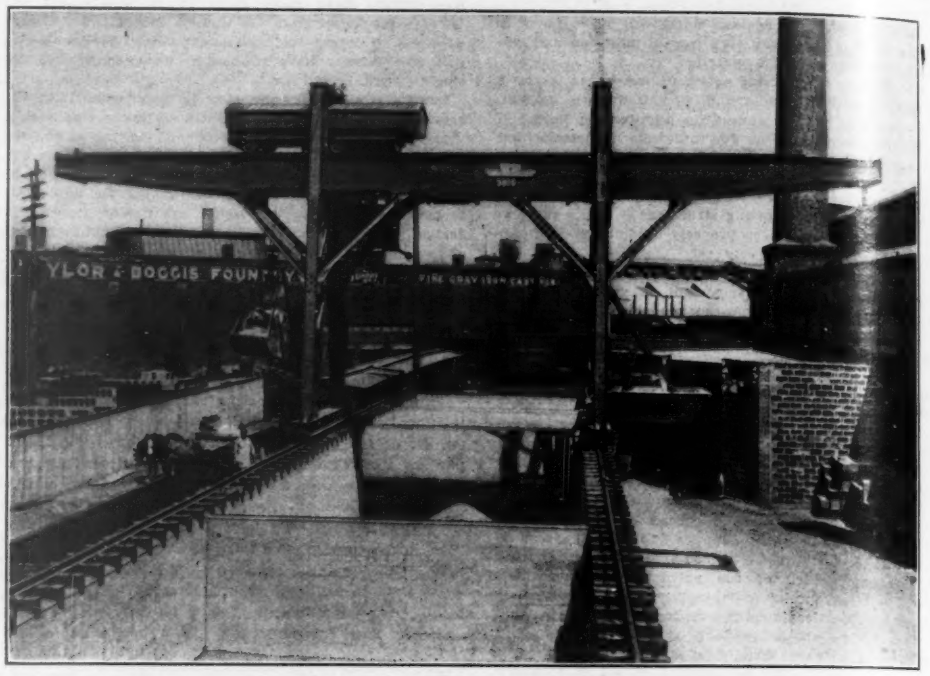
It is proposed to discriminate against every other city and town of this commonwealth in favor of the district within 10 miles of the city of Boston. It is estimated that the cost of electrification in this district will amount to approximately $40,000,000. If the railroads are called upon to make this expenditure in the city of Boston and vicinity; if the proceeds of the securities which the railroad corporations can find the public willing to purchase must be expended in this electrification, then other railroad improvements must necessarily wait. Electrification in other parts of the commonwealth must wait because there is a limit to the amount of money which the public will invest in railroad securities.

If it is understood by the investing public that the Massachusetts legislature proposes deliberately to take the management of its railroads out of the hands of the boards of directors, and to pass that management over to the State Railroad Commission, we venture to assert that investors in Massachusetts railroad securities will be much less willing to add to their investments. We especially recall to the attention of the Senate the report of the majority of the "Big Four Commission" and the statement of Prof. Geo. F. Swain before the joint committees of this legislature.

We respectfully request that the judgment of eleven out of sixteen members of the "Big Four Commission" be followed by the legislature; and that the management of the railroads be allowed to remain with the railroad directors, subject to the supervision, regulation and recommendation of the Board of Railroad Commissioners. We do not in this brief statement consider whether the bill is or is not constitutional.

A Convenient Stone and Sand-[illegible]ndling Plant at Cleveland, Ohio.

A most conveniently arranged plant f[illegible] hand-ling crushed stone, sand and gravel is [illegible]own in the accompanying illustration. An elect[illegible] canti-lever gantry crane equipped with a gra[illegible] bucket runs on rails laid on the side walls of th[illegible] storage



A GRAB-BUCKET CANTILEVER GANTRY CRANE FOR HANDLING SAND AND CRUSHED STONE AT A STORAGE YARD.

bin. Along one side of the bin, at the left in the photograph, is the railway track and on the right is the wagon drive. Thus the grab bucket can be used for unloading material from the cars into the bins and also for loading from the bin into the wagons; or if desired, the stone or sand can be loaded directly from the car into the wagons.

The bin is of reinforced concrete, about 120 ft. long, 30 ft. wide and 15 ft. deep. It is divided by partitions into four compartments for sorting two grades of crushed stone and two of sand. The rails for the crane are laid on short wooden ties bolted to the top of the bin wall. A cantilever extension at each end of the gantry permits the trolley to travel out far enough beyond the wall to pass directly above the railway cars on one side and the wagons on the other. Material can be taken from a car at any point on the track along the side of the bin and can be put into any one of the bin compartments, or into a wagon standing at any point along the bin wall on the drive side.

For convenience in loading the wagons, a riveted steel hopper of 3 cu. yds. capacity is attached to the gantry so as to hang out over the drive. The hopper moves along with the crane so that a wagon can be loaded at any point. The crane, designed and built by the Cleveland Crane & Engineering Co., of Wickliffe, Ohio, is of 3 tons capacity.

At the Wilson Ave. yards of the Cleveland Builders' Supply Co., where this crane is installed, the stone and sand was formerly handled by hand labor at a cost on the average of about $6 per car. The crane, we are informed, effects a substantial saving over this cost and moreover saves much time. The quicker loading made possible by the crane permits of quicker deliveries on rush orders and enables more work to be done per day with a given equipment of wagons and horses. Only one man is required to operate the crane (except when unloading from cars, when the services of a bucket man are necessary) and he can handle from six to eight car loads per day.

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Wanted: More Records of Pioneer Engineers.

We take pleasure in presenting to our readers in this issue reminiscences of some of the pioneer engineers who did heroic work on the surveys of the transcontinental railways two score odd years ago.

Perhaps some readers may object that this space might have better been devoted to some problem in practical engineering work of the present day; but we believe the great majority of our readers are as much interested in the human side of the engineer's work as the scientific side. A few of our older readers may have personally known the men who figured in the events of those exciting days. Younger men cannot fail to find interest and inspiration in the record of the work done and risks run by the pioneer engineers in creating the new West.

We believe more attention ought to be given in engineering literature to adequately recording the life work of those noted members of the profession whose achievements are landmarks in its progress. If engineers themselves are not interested in the noteworthy deeds of their fellows, can they expect the general public to show more appreciation? Undoubtedly the publication of such works as Smiles "Lives of the Engineers" has had a most important influence in causing public appreciation of the work done by the great English engineers of seventy-five years ago.

It would be a great service to the profession to have some able historian tell the story in graphic language of what the leaders in American engineering have done in the past half century. The material for such records must be gathered while it is still available.

In the hurry and bustle of our modern life we do not often pause to reflect that history—real history, profound changes in the life of peoples and nations is being made far more rapidly today than in any preceding age of the world. A decade sees more changes than a century did in the middle ages. And the engineer—using that word in its broadest sense—is the architect of these changes, the real maker of history. A few years hence men will wonder to find so little recorded of the lives and the personalities of the men who have been the chief instruments in molding the world to new forms.

Specifications for Reinforcing Steel.

The specifications for reinforcing steel for concrete, printed elsewhere in this issure, are likely to occupy a position of much authority. Drawn by the influential Committee on Steel of the American Society for Testing Materials, and accepted at the general meeting of the Society, they will shortly be submitted to letter-ballot of all members for adoption as standard specifications of the Society. Judging by precedent, the vote is likely to be favorable. There have been no prominent reinforcing-bar specifications hitherto, and practice in buying and furnishing bars has been quite unsettled and variable. It will doubtless tend to become much more uniform by the influence of the new standard specifications; the latter are likely, therefore, to find close scrutiny on the part of those who have to do with reinforced-concrete design and construction.

Comparison shows that the new specifications are (with three minor exceptions) absolutely identical, word for word, with a specification adopted by the Association of American Steel Manufacturers about a year ago, and printed in Engineering News June 16, 1910, page 704. The changes are that the open-hearth phosphorus limit has been reduced from 0.06% to 0.05%, and clauses 4 to 12 of the new specification added, these clauses relating to inspection and chemical analyses. It will not be surprising under the circumstances to note that the specification effectually rules out re-rolled material. We are not at all convinced that this step is not thoroughly proper. On the other hand, whether the provisions for making the tensile and bending tests are such as to satisfy fully the engineering requirements of the case is a matter which will probably bear careful consideration by those experienced in the work of testing materials of similar shape. It is true that the source of the specification would seem to be a full guarantee that this phase of the matter has been thoroughly considered.

This specification also brings up a point frequently involved in standard specifications. Different kinds of material are described—nominally three, but actually five. The committee that drew the specification probably did not mean to imply that these different materials have equivalent service value. But what will be the user's interpretation? Will he conclude that the specification defines them as equivalent? There is a note in the table of required properties that has some meaning here: "Hard grade will be used only when specified." This phrase, by singling out the hard-grade bars, seems to imply that the other three classes may be used interchangeably, at least whenever the contract fails to name one of them in express terms. And this in turn implies equivalence. On the other hand, the tests on which they are accepted differ radically, and the materials are obviously unlike.

The possibility of doubt would have been avoided if the specifications contained a clear notice that the several materials which it covers do not necessarily give the same service.

A Square Deal in Water Rates.

The demand for a "square deal" which has been a sign of the spirit of recent years is extending to the rates charged for water-supply and other public services, as is brought out in the noteworthy paper on "Water Rates," by Mr. George G. Earl, M. Am. Soc. C E., which we reprint elsewhere in this issue.

The basic principle of the scheme of rates described by Mr. Earl, and illustrated with New Orleans as an example, is a fair division of the cost of service between tax-payers and water-rate payers, with a further fair division between the individual rate-payers or consumers. This is a principle for which we have long contended, but Mr. Earl has put the principle into practical effect at New Orleans and has worked out a plan, based on New Orleans conditions, which may readily be adapted for use in any other community.

The most striking feature of Mr. Earl's New Orleans plan is a combination of a ready-to-serve charge with a flat meter rate. He maintains that once a water connection has been made, a meter set and allowances made for corresponding capital charges and for maintenance, meter reading, etc., it costs no more to supply 1,000 or 10,000 than 100 gals. of water per day. In other words, the sliding scale or the distinction between supplying water at retail and at wholesale is brought into the ready-to-serve charge and the consumer pays a single meter rate, regardless of the consumption. The plan has much to commend it. Those who essay advance criticism should be sure they fully understand it before they try to show up shortcomings.

Mr. Earl's paper and the Metcalf-Kuichling-Hawley paper on Hydrant Rentals, (Eng. News, June 15, 1911) are largely complementary and should contribute largely towards putting water charges on a rational basis—which, with favoritism to none, is all the advocates of the "square deal" can ask. The American Water-Works Association deserves credit for being the medium of putting these papers before the public.

What is the Market Value of an Eminent Scientist?

What is a fair rate of salary for an expert scientist who has risen to eminence in his profession? We believe this question will occur to many of our readers who follow the newspaper accounts of the prosecution (or shall we say persecution?) of Dr. Harvey W. Wiley, Chief of the Bureau of Chemistry of the Department of Agriculture, and the associates who have been working with him to secure the enforcement of the Pure Food and Drug law.

As has been widely published within the past week, a committee made up of the Assistant Secretary, the Solicitor and the Chief Clerk of the Department of Agriculture has recommended the dismissal of Dr. Rusby, of New York, employed for expert work on drugs and drug products, the reduction of Dr. L. H. Kebler, Chief of the Drug Laboratory, and that Dr. Wiley himself, Chief of the Bureau of Chemistry, and Dr. W. D. Bigelow, Assistant Chief, "be permitted to resign."

Attorney-General Wickersham has reviewed the report and recommended its approval with the remark that the offense with which these gentlemen are charged "certainly merits condign punishment."

What was the offense of which these eminent scientists were guilty? It is briefly summarized by Mr. Wickersham himself as follows:

> The evidence submitted by the Committee on Personnel clearly demonstrates the fact that Dr. Kebler and Dr. Bigelow entered into a scheme, to which Dr. Wiley lent his countenance and assistance, to procure the appointment of Dr. Rusby at the rate of $1,600 per year under an express agreement with him that he was to do no more work under this appointment than would be paid for at the rate of $20 per day of 7½ hours when engaged in laboratory work, and $50 per day when engaged in court. The evidence clearly shows that these gentlemen resorted to a scheme to create an appearance of compliance with the law, while at the same time distinctly agreeing not to comply with it.

Since the day when Sergeant Buzfuz portrayed in graphic words the crimes of which Pickwick stood charged, when has an eminent scientist been shown up red handed in more convicting language? Indeed, Mr. Wickersham may yet be known as the Sergeant Buzfuz of this Administration!

It appears that Congress on March 4, 1907, passed a law fixing $3,500 per annum as the maximum salary "of any classified scientific investigator or other employee engaged in scientific work." Dr. Rusby was Dean of the New York College of Pharmacy from 1888 to 1905, is a Past-President of the American Pharmaceutical Association. He has been engaged for some years on special work for the Bureau of Chemistry in the enforcement of the Pure Food

and Drugs Act at a compensation of $20 per day for time actually spent. On May 24, 1909, however, Attorney-General Wickersham gave an opinion that under the law above referred to no scientist could be paid a higher rate of compensation than $9 per day!

Dr. Rusby thereupon offered his resignation, but the importance of his services to the Department was such that efforts were made to find a way by which he could be paid enough to induce him to continue without infringing the law. Dr. Wiley's recommendation for his retention reads:

> I recommend that Dr. H. H. Rusby, now a pharmacognocist in this bureau at a salary at the rate of $9 per day, be appointed as a pharmacognocist at a salary at the rate of $1,600 per annum, to be paid on the miscellaneous roll from the appropriation for general expenses. Dr. Rusby is doing excellent expert work on drugs and drug products, and as a matter of fact it is believed that, there is not a person in the United States who is as high an authority on the subject as Dr. Rusby is. It would therefore be extremely difficult to replace him. His work is necessary to the bureau in the enforcement of the food and drugs act.

The arrangement concluded was that Dr. Rusby should be given an annual salary of $1,600 per annum and should devote 80 days a year to the work of the Department. This arrangement was finally agreed to by Dr. Rusby, not because it was satisfactory to him; but because it appeared to be the best basis permissible under the law. Dr. Rusby's usual fee for testifying as an expert witness in court is $100 per day. He had been doing this work for the Government at one-half this rate and by the arrangement above noted this was to be further reduced to $20 per day, and a maximum compensation for all service given in a year of $1,600.

We do not see how any one of intelligence can read the above account without boiling over with indignation at the dense stupidity—or worse—of the Washington bureaucrats who are responsible for this attempt to destroy the efficiency of an important scientific bureau. Of course a Congressman who places on the statute books a law limiting the compensation of scientists, no matter how eminent or how important to the public interests, to $3,500 a year as a maximum, thereby demonstrates that he himself is receiving a good deal more than his services are worth; but the chief responsibility appears to be with the narrow construction of the law by the official dispenser.

What is an eminent scientist worth? Does any one imagine that the food and drug manufacturers who make enormous profits through the adulteration of the goods they offer to the public limit the compensation of *their* scientific experts to $3,500 per year? When they employ expert witnesses do they get them for $9 per day—the limit set by Sergeant Wickersham? They do not employ the $9 a day kind.

There is no greater obstacle to securing the honest and efficient conduct of Governmental affairs, National, State and Municipal, than the failure to recognize the importance and value of expert service of the highest order. Everybody knows that the success or failure of every private business enterprise depends first of all on the ability of the men who conduct it; and high ability ought to and usually does receive high compensation. The success or failure of Governmental business depends likewise on the competence of the leaders. The public can well afford to pay handsomely the scientists who carry on the fight against food and drug adulteration, and will not approve any conspiracy to destroy the efficiency of Dr. Wiley's department in the interest of food adulterators.

The Bridgeport Wreck and Automatic Stops to Supplement Railway Signals.

The disastrous wreck on the New York, New Haven & Hartford R. R. at Bridgeport, Conn., in the early morning of July 11, has attracted wide attention and will receive the serious study of railway officers everywhere.

It is not because of the number of fatalities that the wreck is notable. Hardly a month passes without some railway wreck in some part of the country recording as large a toll of killed and injured; but this disaster occurred on one of the oldest and wealthiest of American railway systems, where railway operating practice is expected to reach the highest possible standard of safety. The wrecked train, moreover, was one of the most widely known of American express trains. Running between the Capital at Washington and the principal cities of New England, it often numbers among its passengers persons of national reputation, including the President of the United States. It would certainly be expected, therefore, that all the precautions which science and invention can furnish to lessen the risk of railway travel would be in force to make safe the passage of this train over this railway.

The principal circumstances of the disaster were recounted in our last issue but very briefly on account of the limited time available between the hour of the accident and our going to press. A fuller record, with illustrations, is given on another page.

As was made widely known by the newspapers immediately following the accident, the cause of the disaster is officially described to the passage of the train over a cross-over switch at a speed of 60 miles an hour where the train should have slackened speed to 15 miles an hour or less.

This cross-over switch was properly protected by home and distant signals, both of which were displayed against the train. The distant signal was over 2,000 ft. in advance of the home signal, giving the engineer plenty of time to bring the speed of his train under control after passing it before reaching the cross-over. The home signal, too, was a high semaphore close by the cross-over and was plainly visible for 1,500 ft. back along the line. The company states that the signals, both home and distant, and the crossing itself are in the same location that they have occupied for at least ten years.

The engineer who made this fatal error was, it is true, not the regular engineer of this train, but he was a man of fourteen years' experience, during seven of which he had been handling passenger and freight trains in this particular district of the New Haven road. He had made fourteen passenger runs within the past three weeks and had handled this same train on June 25. This engineer was notified, moreover, when he took the train at the Harlem yards, that a stop was to be made at Bridgeport.

In view of all these facts attention ought to be concentrated on one single question: What can be done to safeguard trains against the passage of danger signals? Other questions which came naturally to mind when the first incomplete accounts of the wreck were received are beside the mark. The safety of trains on every mile of their journey depends on the engineer's obedience to signals. Is there any practicable means by which a train can be saved when the engineer fails to apply the brakes at the proper time and bring his train under control?

This is not by any means a new question, of course. It has been forced upon the attention of the public and of railway officials again and again by a long list of fatal disasters due to disregard of signals, extending away back to the first use of fixed signals in railway operation.

For fully thirty years inventors have been working upon schemes to supplement the indications of danger signals beside the track by various devices designed either to warn the engineer who passes a signal at danger or to cause the stoppage of the train independent of the engineer's action. The first class of devices are termed cab signals; the second class have become known as automatic stops. Both of these devices have come into use to a limited extent. In Great Britain the cab signal has met with considerable favor. In the United States automatic stops were used on a suburban railway near Boston fully twenty years ago, and have become quite widely known on account of their use in recent years on the New York rapid transit subway.

Whenever such an accident as that at Bridgeport occurs, the public questions why such devices have not been adopted by the railway companies. One hears it commonly declared that the reason is because railway officers are unwilling to spend money on safety devices and they are roundly denounced for their inhumanity. The public sees no reason why a device used on one railway might not be used on another. It is quite within the possibilities that under the stress of some particularly serious railway wreck, legislation may be enacted, in some State or other making the use of automatic stop devices compulsory.

This position is unjust to railway officers. Many a railway superintendent finds his hair turning rapidly gray with the responsibility of training engine runners to give strict obedience to fixed signals, and the haunting fear, by night and by day, that some one of them may disobey at a critical moment. We risk little in saying that officers of many important railways would welcome the introduction of automatic stop systems or cab signals in connection with the block system, provided they were satisfied that a material increase in safety would actually result therefrom.

The railway official appreciates, better than the public realizes, the extent of the responsibility placed upon him. With a limited amount available to spend on safety appliances, it is his duty to expend that money where it will produce the greatest results in the saving of lives and limbs. For many years those who have had at heart the betterment of railway practice have felt that whatever money could be spared for the introduction of signaling apparatus was better spent to increase the mileage operated under the block system than upon refinements for the mileage already protected by fixed signals. Today, however, there are many railways which have all their heavy traffic lines fully signaled and would be prepared to consider the automatic stop system favorably, provided a system were available for adoption which had been demonstrated to be so practical and reliable that it would not introduce other dangers greater than those it is designed to prevent, and would offer a reliable safeguard against engine runners disobeying signals.

The blunder which inventors of railway safety devices are constantly making, through their ignorance of railway operating conditions, is that in guarding against one danger, which looms large in their minds, they create new and greater dangers which they have not foreseen. As an illustration, suppose the chances are that the average engine runner will run at high speed past a danger signal once in a hundred thousand times. Suppose a cab signal is placed which will sound a warning in the cab when the engine runner passes the signal at danger. May it not be possible that the engineer will come to rely on the cab signal and fail to observe the semaphore? Then, some day, through some mischance to the connections between fixed signal and cab signal, the latter may fail to warn the engineer and he may pass the semaphore without noticing it.

This is an elementary illustration of the difficulties which must be solved before any appliance to supplement fixed signals can be accepted, and of the care with which railway officers must examine such devices. It is not a mere matter, as the public supposes, of appropriating so much money and buying safety devices as one would buy frogs or spikes or train brakes.

On the other hand, we believe that the difficulties we have referred to are by no means unsolvable and that if a moderate amount of capital and engineering skill were devoted to the work, a practicable and reliable automatic stop system could be developed suitable for general adoption in railway service.

Five years ago a terrible rear collision due to disregard of signals occurred at Terra Cotta, Md., close to the National Capital. Congress at that time became impressed with the need that something should be done to make safer the operation of railway trains, and within two months after the disaster it passed a law providing for the investigation of appliances for the safer control of railway trains. Under that law the Block Signal and Train Control Board was organized. In the five years of its existence it has done valuable work in fostering the development of automatic stops. Over 150 devices of different inventors

have been brought to the board's attention, of which 16 have been found of sufficient merit to warrant the board in arranging to test them in regular railway service whenever a working installation should be offered. Of several of these, installations have been made and the board has conducted tests. It can be said, as a result of the board's work, that the development of a practical and reliable automatic stop system is a feasible mechanical problem. This is not saying, however, that such a system is as yet developed. None of the systems which have been tried are perfect. Others which promise well in principle have not yet reached the stage of actual construction. The question which we wish to raise, therefore, is what can the railway companies do to foster the development of such devices as this which we are now considering?

In its last annual report the Block Signal and Train Control Board set forth the reason why a practical automatic stop system meeting all requirements has not been forthcoming. Their statement, which deserves careful reading, is as follows:

> The most serious obstacle to the practical development of systems approved for experimental test has been the fact that proprietors have lacked the financial means needed to carry on their work. Large sums of money have been spent in private enterprises to develop devices which have been found to possess little merit.
>
> It is a matter of common observation, now as for years past, that devices having no merit succeed in attracting capital by methods scarcely less than fraudulent. Instances of this kind have been observed in connection with devices which have been considered by this Board and rejected as worthless. On the other hand, some devices which appear to possess decided merit have remained undeveloped for lack of money or business ability on the part of their inventors. Inventive faculty and business ability seldom go hand in hand.

The situation summed up in a nutshell is this: If a railway company, or a group of railway companies, were willing to invest, say, $50,000 to $100,000 to aid the commercial development of one or two or three of the most promising automatic stop devices, there is every reason to believe that there would be, within a year at most, a device available for use which would add materially to the safety of train movement. Lacking such financial aid, however, it may be many years before any practicable system will be available for adoption.

Money enough ten times over is spent in the United States every year upon the development of railway devices of one sort or other to yield vast benefit in the way of useful and valuable new inventions adapted to increase safety and reduce operating cost. But the trouble is nearly all this money is wasted. It would be hard to find anything in the whole range of commerce which is carried on more crudely than the system—or lack of system—with which new inventions are financed and developed.

We can call to mind now a dozen inventions based on fallacious ideas, on which great amounts of money have been raised, most of which has gone into the pockets of unprincipled promoters. On the other hand there are a dozen other fields of invention where devices which promise to be of great importance to railways are undeveloped because of the inventors' inability to obtain capital for their work.

It seems to us that the time has come when the railway companies of the United States ought to take an active interest in the development of inventions important to the railway service. The automatic stop system is an illustration. This one disaster on the New Haven road may cost the railway company perhaps a quarter of a million dollars or more in payment of damages. If less than half that sum were invested, under proper expert guidance, in the development of a practicable automatic stop system, the way would probably be opened by which the number of accidents on railways everywhere due to the same cause could be largely reduced.

There is no reason, moreover, why investment by railway companies in the development of important railway devices should not be very profitable. An important new railway appliance which is once demonstrated to be practical and advantageous forms the foundation for a very profitable business, but the financial rocks and shoals which lie between the original invention and final success bring shipwreck to all save a very few. Most inventors are unfamiliar with the practical necessities of railway service. They spend the little money they can raise in ways which yield them no benefit. They find it difficult to get a hearing from busy railway officers and well nigh impossible to have their inventions tried, even when they are able to raise the money to have them put into concrete form.

Most of these difficulties could be cleared away at little cost by such an organization as we suggest, and the few inventors who were working in right directions could be aided to success with very moderate outlay.

There is another reason why the railway ought to take an active interest in the development of railway appliances and that is in order that the patents upon them may not be misused. This misuse may occur either through the withholding from public use of some important new device which promises to offer competition to some existing business, or through the demands for exorbitant royalties by the owners of some pioneer patent.

To protect themselves against this latter danger and against unfounded suits for infringement, the railways have had organizations for many years; but all their work has been negative. They only guard against the unprincipled pirates on the sea of invention, so to speak. They have no means and no power to see that when a really important and meritorious railway appliance is developed the owners of the controlling patents upon it shall agree to be content with a moderate rate of royalty.

The older generation of our readers may remember that when the Master Car Builders' type of coupler was adopted, nearly a quarter century ago, through the progressive and public-spirited labor of some of the able railway officers of that day, arrangements were first made with the patentees who controlled this type to make the use of the contour lines on which the coupler was designed free to all manufacturers without payment of royalty.

We cite this as an illustration of what could be accomplished if the railway companies would undertake to foster the development of inventions important for their use and to see that these inventions were handled in a way that would protect the railways' interests. Almost any inventor, for the sake of the financial backing of an association of railway companies to aid the development of his device, would be willing to make an agreement limiting his rates of royalty to a moderate scale.

We believe the time is ripe for the organization of a company with a capital of, say, $1,000,000 or more, under the auspices and control of the American Railway Association, which should have as its object the development of new inventions of importance to the railways of the United States.

Such an organization could take over a good deal of work in testing and investigation which such railway associations as the Master Car Builders and Master Mechanics and Railway Engineers' Association are now doing (or would like to do) and could do it much better because organized on a business basis with the capital to carry on work in a businesslike way.

It could effectually supplement the work of the Block Signal and Train Control Board and utilize what that body has accomplished by taking a financial interest in some of the inventions of greatest promise.

The objection will be made, without doubt, that it is impossible to tell what devices are promising and what are not, and hence investments made by such a company would be like investments in a lottery. Such a view, however, is wholly incorrect under present-day conditions. The Board just referred to, though an official government body, does not hesitate to say what inventions are hopeless and what are promising in its field of work. We could easily suggest the names of half a dozen engineers of high standing in railway circles who would be competent to act as an advisory board for such an organization, and could ensure that the great proportion of its ventures would yield a profit both direct and indirect. Of course, it will be admitted that some uncertainty attaches to any such work as the development of new inventions, but it is the business of a competent engineer to discern which paths are open roads and which are definitely closed.

While we have taken the automatic stop device as an example of the work for the railway companies which such an organization could do, there are dozens of other directions in which work urgently needs to be done to safeguard the financial future of our railway companies. Take, for example, the question of the future tie supply. Dozens, if not hundreds, of inventors are working on various forms of railway ties of reinforced-concrete. Nine out of ten of them probably are working in totally wrong directions. There is a possibility, however, that some few may have ideas which are capable of development on successful lines, and whose development would mean a saving of tens of millions of dollars to the railway companies only a few years hence, when the inevitable famine in timber supplies becomes severe.

The friendly advice and aid of such an organization could save a lot of poor inventors from wasting their time and money and annoying railway officers with schemes impossible of success; and might, on the other hand, secure for the railway companies the development of a great improvement in permanent way, which would be available to them at moderate cost.

Railway bridges and tracks have suffered damage for many years from the salt water dripping from refrigerator cars. Year after year various associations have "set" on this question and have hatched nothing with any life. The Atlantic City conventions last month developed nothing except more reports of difficulty. The fact is that under the present organization of our railway companies *it is nobody's business whatever* to see to it that such mechanical problems are solved, and solved promptly and correctly.

For lack of just such an organization as we are suggesting, the adoption of a type of automatic car coupling was delayed by five to ten years, and the adoption of a standard coupling has been delayed more than a dozen years.

There are details of locomotive construction which ought to be overhauled and radically improved, and large saving could be thereby effected; but the railway mechanical officers are too busy with routine work to give attention to such improvements. It is doubtful whether such inventions would be adopted even if developed unless they had the backing of some such organization as we have suggested.

One of the best illustrations of the value to the railway companies of systematic scientific work in the development of railway appliances is the air brake. Suppose it had happened that the air brake, instead of being invented by a man of Mr. Westinghouse's genius and business ability, had been invented piecemeal by a dozen different inventors. Suppose it had been carried on by one and another with the usual squabbling over patents and trifling details and that no one of them had been able to command the capital to have the brake designed and manufactured with all the advantages of expert engineering talent and high-grade workmanship. Had the air brake been developed under such a system, as might well have happened, the loss to American railways in increased operating expenses and increased accidents might easily have amounted to tens of millions of dollars every year. The fact is, however, that a good many railway appliances in extensive use to-day are as crude and defective in design as the air brake would have been had it been developed in the blundering, happy-go-lucky way of most other railway devices.

What we are urging is that the railways themselves, through some organization formed in their interest, shall apply to the development of railway appliances and inventions the same high grade scientific expert work that has been devoted to the development of the Westinghouse brake.

National attention was attracted a few months ago to the declaration that the railways of the

United States could save a million dollars a day by the adoption of "scientific management."

One of the first principles of scientific management is that all tools and appliances shall be the best that can be devised. Some of the most noted achievements of efficiency engineers have been the development of new inventions to take the place of devices which had been used so long that those closest to the industry did not suppose anything better was possible.

The first and easiest step toward the economies possible by scientific management which the railways of the country could take would be to foster the development of better and more economical devices. They cannot longer afford to leave this matter to chance and accident. If the inventor of a meritorious device cannot find backing to develop his invention without associating with promoters of fake enterprises, it is a matter of even more moment to the railways than to the inventor.

It may be said that the great inventions of the past half century have been made without such aid; but conditions have radically altered in the field of invention. Improvements to-day must be made along scientific lines and involve a degree of expert knowledge and an amount of research, investigation and outlay that was not dreamed of a quarter century ago. Compare, for example, the original invention of the block system with what is required to-day to add to the present complicated block signal system an automatic stop.

If, therefore, we are to see progress in railway operation in the next quarter century equal to that of the past, the improvement of railway appliances must be aided and fostered and not left to blind chance.

LETTERS TO THE EDITOR.

A Dam Made Up of Arches.

Sir: By a mischance my copy of Engineering News for June last year was mislaid and I have only come across it to-day, and read for the first time Mr. John S. Eastwood's interesting letter about arched dams. So slow, however, has been the advance in this branch of engineering that I need not apologize for directing your attention and that of Mr. Eastwood to a design which I had, some time before, evolved from first principles and with only such encouragement as was afforded by the then existing examples of dams of arches, none, I think, more than 50 ft. in height above ground.

My finished plans, for a dam 185 ft. above ground and 200 ft. above foundations, are dated Sept. 30, 1909. In January, 1910, and subsequently my plans were made known to a number of engineers, but were not published till last February and March, when a brief but sufficient description of the design, with diagrams and with a short discussion of the general position as regards mass dams, appeared in "The Engineer," the issues of Feb. 24 and March 3. In the meantime American engineers had been groping their way towards the idea of direct thrust, which direct thrust I attained in my design *by making it the basic idea*, treating the problem as a new one and disregarding altogether the lump-of-masonry idea which still dominates or vitiates almost every dam design. Mr. Eastwood's description of the mass dam, "a huge mass of poorly disposed material to resist uncertain and unbalanced stresses," is a good one; though I prefer it without the words "and unbalanced"; and, for my part, I make the reservation that the mass dam is the most suitable type under *some* conditions, though the dam of arches should be regarded as the typical river valley dam. I think that my type would be regarded by Mr. Eastwood as designed on definite principles and in a rational manner, and the fact that my first actual design was for a dam 200 ft. from foundation to crest and 185 ft. above ground, with a stress of 15 tons per sq. ft. in the arches and 10 tons per sq. ft. in the buttresses, puts it at once into a different class from low weirs and dams 50 ft. or so above ground.

A distinctive feature of my dam is that the water face is at right angles to the outline of the buttress. I show it at 45°, the most economical angle for such a dam, though other angles steeper or flatter (usually flatter) would be better for some special cases.

I can find no existing example of a dam, built or designed, in which the water load *near the top* is conveyed to the rock by direct thrust, and I can find no example of a dam with a buttress in parallel layers at right angles to the water face. In my dam, if built of natural stones, the bed planes in the buttress would be parallel to the water face; if of concrete, blocks would be used in the same way.

If higher stresses be allowed much higher dams of this kind can be built, that is, much more than 200 ft. above ground. No existing mass dam of any considerable length is really more than about 150 ft. above ground. To bury 100 ft. depth of masonry in hard ground and build a dam 150 ft. high on that is very different from designing and building a dam 250 ft. high.

Nothing in this letter refers to dams of one arch closing gorges. That problem is quite a different one.

Reginald Ryves.

West View, Bent's Brook, Dorking, England, June 12, 1911.

Locomotive Truck Swing—Exact Formulas.

Sir: In your issue of June 8, 1911, p. 700, under the above heading, Mr. H. C. Weaver gives formulas for determining the swing of four-wheeled and two-wheeled trucks on curves. The writer does not agree with Mr. Weaver's statement that they are exact in all cases, for they are correct *only* if the locomotive, while passing a

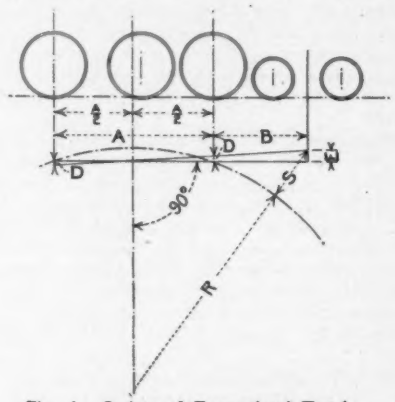


Fig. 1. Swing of Four-wheel Truck.

curve, has the flanges of the front and rear outside driving tires bearing against the outer rail, or equidistant from it. That may be the usual position; but the position which will give the *maximum* swing is with the locomotive angling across the track, with the flange of

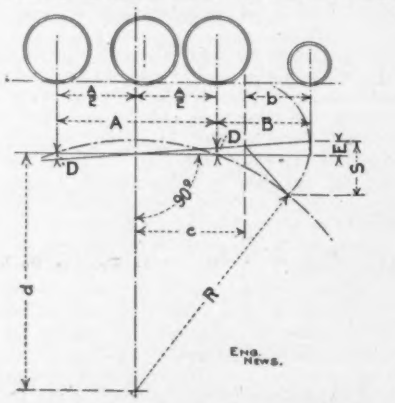


Fig. 2. Swing of Two-wheel Truck.

the front outer driving tire bearing against the outer rail, due to centrifugal force, and the flange of the rear inner driving tire bearing against the inner rail, due to drag of train. This may occur when running at a speed somewhat less than the maximum for which the outer rail is elevated.

The maximum angularity in distance *A* (rigid wheelbase) will be the sum of the total play between tires and rails plus the total play between driving boxes and wheel hubs. This angling action will increase the swing of the truck as given by Mr. Weaver by an amount proportional to the distance from center of rigid wheel-base to center pin of truck (see formula 1 below). As the gage of track is usually increased on curves, thus increasing the play of the wheels on the rails and the angularity, it is evident that the actual gage should be known when the clearances are very small.

Let A = length of rigid wheelbase;
B = distance from center of front drivers to center pin of truck;
b = length of radius bar;
c = distance from center of rigid wheel-base to radius-bar pin;
D = ½ (total play of wheels on rails plus total play between driving boxes and wheel hubs);
E = increase in swing of truck due to angling across track;
R = radius of curve;
S = ½ total maximum swing of truck;
(all dimensions to be expressed in terms of the same denomination);

then $E:D = (\frac{A}{2} + B):\frac{A}{2}$, from which

$$E = \frac{(A+2B)\,D}{A} \qquad (1)$$

Adding E to Mr. Weaver's formulas we have the following for maximum swing each side of center:

For FOUR-WHEEL TRUCK (Fig. 1),

$$S = \sqrt{R^2 + B\,(A+B)} - R + E \qquad (2)$$

For TWO-WHEEL TRUCKS (Fig. 2),

$$S = \frac{b^2\,d + b\,c\,R}{b^2 + R^2} + E \qquad (3)$$

The maximum swing of a radial type trailing truck will occur when engine is backing, and may be found by Formula 3.

E. M. Crawford.

American Locomotive Co., Schenectady, N. Y., June 22, 1911.

A Reasonable Return for Fire-Hydrant Service.

Sir: The undersigned was greatly interested in the paper by Messrs. Metcalf, Kuichling & Hawley, discussing the cost of fire-protection service as abstracted in your issue of June 15, particularly by reason of his part in the work of the engineering staff of the Railroad Commission of Wisconsin, including, as the work of said staff has, the apportioning of the values of water-works properties in this state between fire service on one hand and domestic and industrial service on the other. The values apportioned have, of course, been the detailed estimates made for the Wisconsin commission by its engineering staff, those figures being customarily submitted as "tentative valuations" and considered by the commission along with all other available evidence of the values of such properties in its decisions in rate and other cases.

The making of such apportionments has obviously involved more than passing consideration of the points so ably discussed by the authors of the paper above referred to. As the writer does not enjoy membership in the American Water Works Association he has not had the opportunity to participate in the discussion which the paper doubtless had when first presented. There are a few remarks which I desire to make in reference to the same and, apparently, the only channel for discussion on my part is your paper, which I trust may be open to me.

I shall confine my remarks to questions involved in apportioning the physical value of a water-works between the two primary divisions of service and not refer in a more than an incidental way to operating expenses or other elements entering into the total cost of either fire protection or domestic and industrial service.

The questions involved will be seen to refer generally to only a major part of the entire physical property value when it is considered that the values in certain parts are chargeable wholly to one service or the other. Hydrants, and the pipes connecting them with the mains, belong wholly to fire service; service pipes, if these be part of the property, instead of having been paid for by the consumers as is sometimes the case, are chargeable to domestic and industrial service. If there be a small elevated tank or water tower on the system which is customarily shut off from the mains in case of fire, its value should be charged into the property devoted to the domestic service. There is usually a certain amount of small mains on which no hydrants are connected and fire protection is not chargeable with any part of their cost or value.

The common system of mains usually represents so large a part of the total physical plant value that the apportionment of its value becomes probably the most important consideration in relation to this matter.

The authors of the paper above referred to have called attention to the variation in the relative and absolute amounts of water required in different parts of a system and to the fact that a general formula applicable to an entire system cannot be derived. It does not seem, however, that sufficient stress was laid upon these facts. There appears to be a tendency to consider the formulas derived as applicable to the entire common system of mains.

Only the *total* actual and relative demands of the two service divisions appear to have been discussed and used in the derivation of the formulas presented, and the only place where the total demands of the two service divisions occur together is in the main artery of the system, or the pipe line from the pump to the first three-way or four-way special casting, where the flow is divided.

Hence it would appear that the formulas and percentages are applicable to that part of the system and that part alone unless further analysis justifies the use of the same ratios in apportioning the system as a whole.

It will be found by reference to reports of the National Board of Fire Underwriters that the quantities of water mentioned in the paper under discussion as the requirements of the National Board for adequate fire service in cities of various sizes are for the factory and business districts of those cities. The same reports frequently, if not commonly, specify that the distributing mains be designed to supply a minimum of 2,000 gals. per

min. for a fire in any outlying residence district, also that the pressure at the hydrants with 2,000 gals. being drawn per minute be not less than 60 lbs. per sq. in. Apparently the use of 6-in. pipe for outlying residence districts is approved by the National Board, but no smaller size is so approved, and grid-ironing, or cross-connecting of parallel mains, is generally recommended.

It is doubtless true that practically every water system has several dead-ended mains, one or two blocks or more in length, around its borders, each of which supplies a few consumers and also one or two or more fire hydrants. One of these may be taken as a simple and typical case for analysis in apportioning the system.

The flow of water in any such pipe line occasioned by domestic service alone would be comparatively small and would decrease to only a slight amount at the last tap or service connection. Doubtless a 2-in. or even smaller pipe may safely be considered adequate for existing domestic service alone, although, owing to possible or probable growth of consumer population on the assumed line or the extension of the line itself, it might appear unwise to actually lay so small a pipe as would just be adequate for existing consumers.

The furnishing of but two 175-gal. streams or 350 gals. per min. from the hydrant at the end of a separate fire service main in the same location, with a pressure loss not exceeding 14 lbs. per thousand feet of main will require a 5-in. pipe. This is not a standard size in cast-iron pipe, but for the purpose of apportioning the value of existing 6-in. mains in such localities it may be assumed as a standard and its unit value estimated by interpolation between the unit values of 4 and 6-in. lines.

The unit values of 2-in. galvanized and 4-in. and 6-in. cast-iron mains used by the staff in the valuation of a certain Wisconsin water-works plant were, respectively, 29 cts., 61 cts., and 82 cts., exclusive of hydrants, valves, special castings, etc. The unit value of 5-in. pipe line would then, by interpolation, be 71 cts. The above figures are in the ratios of 1.0, 2.1, 2.45 and 2.83, for 2, 4, 5 and 6-in., respectively. The carrying capacities of the same pipes, figured on the same loss of pressure per thousand feet of line are in the ratios 1.0, 6.6, 12.1 and 20.

The writer is of the opinion that the value of a water main system rendering both fire and domestic service should be apportioned between those divisions on the basis of relative costs of separate systems for the two classes of service. A common system for both is undoubtedly more economical than separate systems and both classes are entitled to share in the economy. If there be a shortage or a surplus of capacity in such common system the under or over investment represented thereby is also to be divided between fire and private service. There are some who would claim that a certain system is inadequate for the simultaneous maximum demands of fire and private service and who would argue and have argued, that a separate system for adequate domestic and industrial service alone should be about as large throughout as the existing system, therefore, they say, there is little or no investment in existing mains which is chargeable to fire service, and the hydrant rentals must be very low.

Reverting again to the above figures on relative costs of separate lines of pipe for domestic and fire service in outlying districts, which figures are merely assumed for purposes of illustration, it will be seen that the typical 6-in. main, costing 82 cts. per ft., would be apportioned as follows, on the basis of relative costs of separate mains:

$$\text{To Domestic Service } \frac{29 \text{ cts.}}{29 \text{ cts.} + 71 \text{ cts.}} = 29\%$$

$$\text{To Fire Service } \frac{71 \text{ cts.}}{29 \text{ cts.} + 71 \text{ cts.}} = 71\%$$

On the basis of relative required *capacities* of separate mains, which does not appear to be a proper basis for apportioning the value of the typical common main in question, the apportionment would be:

$$\text{To Domestic Service } \frac{1}{1 + 12.1} = 7.6\%$$

$$\text{To Fire Service } \frac{12.1}{1 + 12.1} = 92.4\%$$

Frequently other parts of a system may be readily apportioned by similar analyses based on certain assumptions. The percentages finally applied to the system as a whole will certainly lie between those determined for mains nearest the plant and those most remote. The location of a plant with respect to center of distribution will affect the results to some extent since this determines the proportion of the whole private service which is carried along with the fire service, and this, in general, will be the same in any direction from a centrally located plant. The domestic consumption (including all use of water except fire service) will naturally tend to decrease with some uniformity with increasing distance from the plant, hence the sizes of mains required for domestic service alone can decrease much more rapidly than could separate adequate fire systems.

One other point discussed in the above-mentioned paper to which I would call attention is the question of the proper ratio between the average rate of domestic consumption and the rate which should be considered to exist with fire service.

The authors have based certain of their calculations on the assumption that without fire service the maximum rate of domestic consumption is twice the average and that *with* fire service the domestic consumption may be taken as 1½ times the average. The writer would not take exception to this in the case of water-works in large cities which regularly use fire engines and do not have greater pressure in the mains in times of fire than is ordinarily maintained for other and more regular service, but the effect of fire pressure upon the rate of domestic consumption is an important consideration and should not be overlooked.

The water plants in most cities of less than 50,000 population usually increase the pressure 25 to 100%, more or less, above the normal, on receipt of a fire alarm and furnish good streams without the city's use of fire engines. The result is that every open tap and leak discharges water at a higher rate. Furthermore, there may be weak, self-closing faucets or other fixtures which give way under the higher pressure, resulting in more openings.

The writer was recently in a pumping station at a time when the rate of total domestic and industrial demand under the normal pressure (75 lbs.) was approximately 4,000,000 gals. per day. At his request the stand pipe valve was closed and the pressure was raised to 115 lbs., that being about what is carried for fire service. No fire streams were used and no additional openings made from the system, so far as known. The pumping rate, however, increased to 7,000,000 gals. per day. When the pressure was reduced to normal the pumping rate dropped to 4,000,000 gals. per day.

The recent average daily consumption in that city is about 3,000,000 gals., but the maximum pumping rate, under normal pressure, has reached 7¼ million gallons per day on several occasions, some of which were in the forenoon, and no water was being used for fire fighting.

Considering the effect of increased pressure upon the rate of consumption in domestic and industrial service, also the fact that bad fires (not general conflagrations) frequently last many hours and last through hours of the day when domestic service is heavy, it would seem that correct design requires the use of a larger factor than 1½ applied to the average rate when coupled with fire-service demands.

The extra amount of water used per unit of time by domestic and industrial consumers under fire pressure over that which would be used at the same time under normal pressure is a result of the combination of fire and private service into the business of a single common system. Such extra capacity and investment as may exist to provide for this abnormal domestic demand should be shared equally by fire and all other service.

Yours truly,

W. E. Miller, Assoc. M. Am. Soc. C. E.
Civil Engineer Inspector, R. R. Com. of Wis.

Madison, Wis., June 20, 1911.

New York City's West-Side Freight Problem in the View of a Railway Operating Official.

Sir: I have read your editorial in regard to the economical handling of freight on the North River water front with a great deal of interest, as the subject is a very important one.

In approaching this subject there is one thing that always appears most prominently, and that is the fact that Mr. Tomkins has endeavored to handle it from a very broad standpoint, and it seems to me has earnestly tried to arrive at a proper conclusion from the standpoint of what is best for all concerned.

It seems to me in considering the matter that there are a number of points of mutual interest from the viewpoint both of the shippers and of the railroads.

The trouble about Mr. Tomkins' proposition is the large amount of artificial movement that is created in carrying out his plan. There is no question but that the movement to-day is as nearly along the lines of least resistance as it probably can be made, as it merely consists in putting cars upon floats and floating them across the river alongside the pier freight-houses, so that the floats fulfill the same function as the house tracks in the ordinary local yard. At night when the cars are loaded to go out on the road they are simply floated across to Jersey City, taken off and dispatched. In Mr. Tomkins' plan there is involved the floating of cars to a point somewhere above Thirtyninth St., then unloading them on floatbridges, then transporting them by elevated railroad to some point (or points) where freight depots may be had, and the reverse operation in the opposite direction.

This means the concentration of a large amount of facilities where the floatbridge facilities are located on the Manhattan side. It is my impression they will take up the equivalent of a very large percentage of the room to-day occupied by the railroads, and this large amount of occupied space will be concentrated at one point instead of being scattered over the North River front as is now the case. I do not believe, therefore, that the pier relief will be as great as anticipated. I believe that the space which would be occupied by these floatbridges can be utilized in such a way as will enable the furnishing of practicable locations to many of those now desiring to be located on the North River front. I also believe it is possible to move some of the occupants of the North River front over to the East River. I think, in short, that there is enough space on Manhattan Island to furnish locations to those who should have them, if the space is thoroughly laid out so as to locate the parties desiring such locations in that manner which will redound to the best advantage of the city.

I believe there will be great difficulty in operating the elevated railroad unless such a superabundance of facilities is provided as will make it so expensive that the investment will be entirely too large. Certainly it would not pay the railroads to invest in such a proposition by themselves.

You describe in your editorial a number of difficulties which would be attendant on the operation of such a line. These difficulties have occurred to most men who are familiar with the operation of such railroads. There is one thing that you call attention to in your editorial, which, I think, is worthy of more consideration than it seems to me has been given it, that is, the necessity of ample yard room at the proposed floatbridges. As the business grows larger it will be necessary to provide more and more space, and as lands in the vicinity of Fortieth St. become more valuable it will entail considerable expense to furnish room necessary for such a yard, in fact it is questionable whether it will not finally become impracticable to provide such room.

There is another important feature in connection with this scheme, which you do not touch upon but which is of very great importance, and that is the question of time. The railroads are to-day running fast freight trains from New York City to Chicago in 60 hours, and to intermediate points in a proportionately shorter time. The freight houses now close at 5 o'clock. I believe that if this scheme is put into effect, in order to get our freight trains out of Jersey City the same time we do now it would mean the closing of the freight houses at 3 o'clock, and we are running our trains as fast as we should under present conditions. So far as the fruit business is concerned, I do not believe it could be handled under this system because of the delay.

Another question that comes up is that of expense. I have endeavored to make as close figures, to make as many offsetting allowances as seem advisable, and to be as conservative as possible with reference to this phase of the proposition so as to not unduly favor the present method of handling business, and the figures I have made indicate that *it will cost us 43 cts. per ton more to* handle the freight under such an arrangement as compared with present conditions. Some one will have to pay this amount, and I am sure that the railroads cannot afford to do so.

With reference to the establishment of a Union freight-house. As a general proposition the railroads have been somewhat averse to the establishment of a Union freight-house, for perhaps the same reason that people in other lines of business do not seem to be disposed to establish Union stores. To-day the only thing that is left for the railroads to differentiate in, as between themselves, is the prompt and efficient handling of their business; therefore they naturally desire to keep this under their control.

The railroads having depots on the North River front now generally do sufficient business at each one of their depots to justify their having them, and I believe it is better from a teaming standpoint to have the facilities in this way than to have them all concentrated, as if they are concentrated I am satisfied there will be much congestion. The Terminal Association Joint Depot at St. Louis, which is so often cited as an example of a joint freight depot, does not, to my mind, convey any criterion by which New York City conditions can be judged. They do not handle anything like the business that New York does and it is also a fact that all the railroads have their own depots notwithstanding the fact that this terminal depot can be used by them. As may be known, the M. K. & T. R. R. interests have recently erected a very fine freight layout at St. Louis, which would hardly be done if the Terminal depot was of such moment as to render it an efficient terminal for them.

So far as the "Proposed unit terminal system" is concerned, it seems to me that about as many piers will be used under this scheme as are now used, and it means we would not only have the investment on the piers to pay for, but also the investment on the back lands.

I believe, as you state, the introduction of the motor driven truck is going to mean that some facilities can be located on the Jersey side of the river which will tend to relieve the situation.

It may be thought that I am pleading for the established state of affairs *because* it is the established state of affairs, but I have tried in my thought on the subject to attain such a state of mind as would lead to a consideration of the situation with the idea of arriving at a proper solution for all concerned. It seems to me that the schemes which have been proposed are arti-

ficial; that the piers could be remodeled, second stories put upon them, and the capacity thereby greatly increased and the congestion on West St. diminished by using the lower floors of the piers for driveways and storage and the upper floors for storage, in other words, adapting them more for railroad freight purposes than for steamship purposes (for which they were naturally originally designed). This, I think, will help out the teaming.

W. J. Harahan, Vice-President, Erie R. R. Co.
30 Church St., New York City, July 6, 1911.

Retaining Walls With Loaded Filling; Rational Method for Determination of Pressure.

Sir: The problem of the determination of lateral pressure on retaining walls due to a fill carrying concentrated loads is one that arises frequently. Most engineers will recall offhand typical examples. For example, a retaining wall along a river front may have to support a railroad track, subject to heavy train loads, located back a few feet from its face and running parallel to the wall. Or, a line of piers forming footings for columns of a

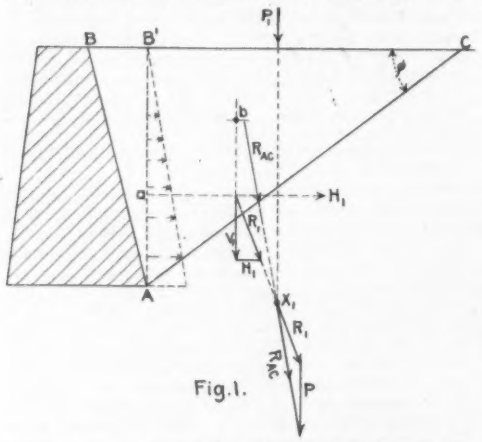


Fig.1.

building may be located ten to twenty feet back of the face of such a wall, with the footing of the piers located a few feet below the top of the backfill.

The writer recalls only one method of investigation of the lateral pressures on such a wall as being given in treatises on this subject. This method is to assume an additional fill above the top of the wall, the weight of said filling being so assumed as to be equivalent to the superimposed load. In several cases within the writer's experience it was not at all apparent that such a treatment approximated the actual conditions; in other words the assumption of a level fill seemed "far-fetched" as applied to the actual conditions.

The method which follows, for determining the resultant pressure on an inclined wall due to a loaded fill, has been evolved by the writer, and seems to give reasonable results. Since the line of procedure given ap-

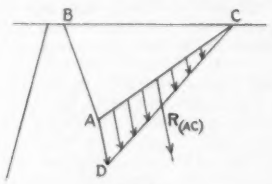


Fig.2.

pears to be somewhat of a departure from theories generally used, it might be of interest to your readers.

Let it be required to find the magnitude, direction, and point of application of the resultant total pressure on the retaining wall AB, Fig. 1. The backfill is level, weighs w per cu ft., has an angle of repose $= \phi$; and carries the superimposed load P_1 per foot of wall. The distance from B of the center of gravity of the load (or system of loads) P_1, will of course be known, and is assumed to be correctly represented to scale in Fig. 1.

From A draw AC, the plane of repose, at an angle ϕ with the horizontal and cutting the surface at C. First we find, by the usual procedure of the Rankine theory, the pressure on the plane AC due to the fill alone, as follows:

$$H_1 = \tfrac{1}{2}\, w\, (AB')^2\, \frac{1-\sin\phi}{1+\sin\phi}.$$

The total pressure on the vertical plane AB' will be

$$H_1 = \tfrac{1}{2}\, w\, (AB')^2\, \frac{1-\sin\phi}{1+\sin\phi},$$

acting horizontally at a distance from A equal to $\frac{1}{3}\, AB'$. The weight of fill $AB'\,C$ is called V_1, its line of action being vertical and passing through b, the center of gravity of the area $AB'\,C$. Then the resultant pressure on AC, due to the fill alone, R_1, acts through the intersection of H_1 and V_1, and is given in magnitude and line of action by the triangle of forces at this intersection, R_1, V_1, H_1. Thus far the procedure will be familiar to all.

Now produce the vertical line of action of the superimposed load P_1 to intersect the line of action of R_1 at a point x_1. The resultant pressure on AC due to both fill and superimposed load will then pass through this point x_1, and will be given in magnitude and line of action by the triangle of forces at x_1. Drawing this triangle the closing force is found to be R_{ac}, which is the total resultant pressuce on AC due to both fill and superimposed load.

Now referring to Fig. 2, let AD be the pressure per foot at A on the plane AC. It will act parallel to the

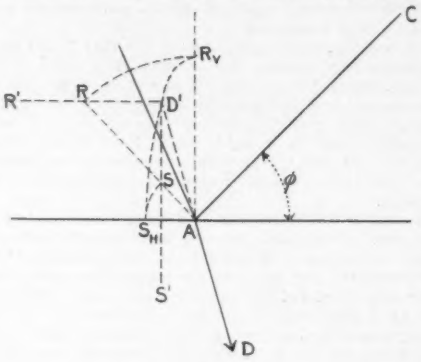


Fig.3.

resultant R_{ac}, and Fig. 2 shows that $\frac{1}{2}\, AD \times AC = R_{ac}$, whence $AD = 2\, R_{ac} \div AC$.

We know in magnitude and direction the pressure per foot at the point A on plane AC due to both filling and superimposed load. This is sufficient to determine the ellipse of stress at A, from which we can then determine the pressure at this same point on the plane AB. It is necessary next to construct this ellipse of stress at point A, knowing only the direction of maximum stress (which is vertical) and the magnitude and direction of a conjugate stress AD on a plane AC of inclination ϕ to the horizontal. Fig. 3 sketches the procedure.

For clearness in the diagram, produce AD upward to D', making $AD' = AD$. Through D' draw the indefinite line $D'R'$ horizontally, and $D'S'$ vertically. From A draw

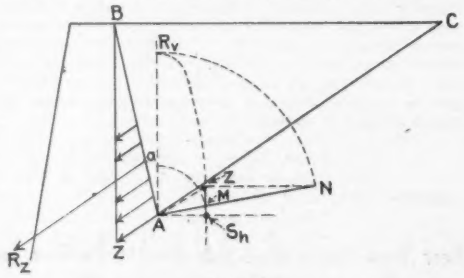


Fig.4.

a line perpendicular to AC. It cuts $D'R'$ at R, and cuts $D'S'$ at S. Then AR is the length of the semi-major axis and AS is the length of the semi-minor axis of the ellipse of stress at A. Lay off vertically $AR_V = RA$, and horizontally $AS_h = SA$, then:

Maximum pressure at $A = \overline{AR}_V$ acting vertically.

Minimum pressure at $A = \overline{AS}_h$ acting horizontally.

The curve $S_h\, D'\, R_V$ is the ellipse of stress at point A.

It will be noted that the above is the exact reverse of the usual construction given for the ellipse of stress with level filling. Usually the amounts of maximum and minimum stress are known and it is required to obtain a conjugate stress on a plane at an angle with

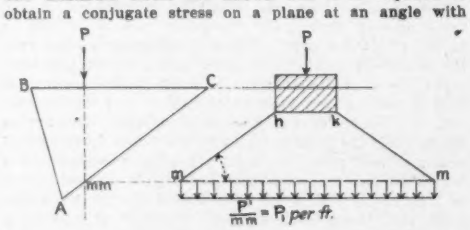


Fig.5.

the planes of principal stress. Here the known quantities and unknown quantities are interchanged.

Lastly, having constructed the ellipse of stress at A, we are enabled to obtain the pressure on plane AB (the face of the wall) at A, and from it the total resultant pressure on AB (see Fig. 4).

Draw arcs with A as center and radii AR_V and AS_h (the max. and min. pressures just found). Draw AMN perpendicular to AB through A to intersect these arcs at M and N. Draw MZ vertically from M, and NZ horizontally from N to intersect at Z. Then Z is a point on the ellipse of stress at A, and ZA is, in magnitude and direction, the unit-pressure on plant AB at A.

Pressure triangle ABZ on AB then gives the total resultant pressure on AB, the face of the wall: $R_x = \frac{1}{2}\, AB \times AZ$, acting at a (Aa being equal to $\frac{1}{3}$ of AB) and parallel to AZ.

When the superimposed load consists of one or more concentrated loads, say a line of building columns parallel to the wall, the uniform load P_1 per foot might be found as indicated on Fig. 5, hk being the length of the base of the pier parallel to the wall. The load per foot then might be taken as $P_1 = P \div mm$.

The writer would say, in closing, that he would appreciate any comment or criticism of this analysis which might be offered by your readers.

E. K. McDowell.
American Steel & Wire Co., Donora (Pa.) Steel Works, June 17, 1911.

The Appointment to the Position of State Superintendent of Highways of New York.

Sir: In view of the interest felt by engineers generally in the New York State Highway work, the proposed changes in the organization responsible for the conduct of that work have been followed with special interest. If I mistake not, Governor Dix, in recommending to the Legislature the abolition of the State Highway Commission, intimated that it was his intention to place the work of state highway construction in charge of the most competent highway engineer that could be found in the country.

It was indeed reported in the newspapers that the position had been offered to Mr. Harold Parker of the Massachusetts Highway Commission (before the position was created) and had been refused.

On July 17, however, Governor Dix nominated for this position William H. Catlin, of Port Chester, at a salary of $7,500 per annum. The newspapers say:

> Mr. Catlin has lived in Westchester for more than forty years, and, in addition to managing his extensive farm near Port Chester, has devoted much of that time to the development of real estate. He is considered an efficient road builder. He is about 70 years of age.

These are the qualifications, then, which fit a man to be placed in responsible charge of the largest amount of highway construction undertaken by any state in the Union!

There is, however, another item in this connection which is of special interest to engineers. Mr. John A. Bensel, the present State Engineer of New York, is a chief adviser of Governor Dix and is a Past-President of the American Society of Civil Engineers.

One might reasonably suppose that as an engineer of high standing who has received high honors at the hands of his professional brethren, Mr. Bensel would have exerted his influence to have this important position filled by a high-class engineer. Perhaps he did; but the account given by the New York "Times" is as follows:

> The appointment of Mr. Catlin had been advocated very earnestly by State Engineer Bensel in the face of the contention that the State Superintendent of Highways ought to be an engineer well versed in the art of road building. Mr. Bensel, it is said, was anxious that the man to whom is to be entrusted the task of constructing good roads for the State should not be an engineer. The appointment of Mr. Catlin, it is generally regarded here, will leave Mr. Bensel, who is an engineer, the dominant figure on the new State Highway Commission, which is to be composed of Mr. Catlin, Mr. Bensel and State Superintendent of Public Works Treman.

In view of the statements of Mr. Bensel regarding the New York State highway work which were published in your issue of Feb. 9 last, I believe the above is of general interest to the profession and solicit a place for it in the columns of your journal. C. E.

New York, July 18, 1911.

Notes and Queries.

J. B. H. desires to obtain data concerning the practice of using metal monuments, made of aluminum or brass disks, set in concrete sidewalks to mark street or property lines. Such monuments have been quite extensively used for marking survey points on boulders or ledges and on cut stone monuments. We would be pleased to hear from our readers regarding their use in concrete walks in cities. As most surveyors are very well aware, there are many of our American cities where street or property lines are very poorly established. A cheap and durable monument has been long sought after and it is possible that metal disks thus set would be as little liable to molestation as anything that could be had at low cost.

Robert W. Blackwell & Co., Ltd., 14 Great Smith St., London, writes:

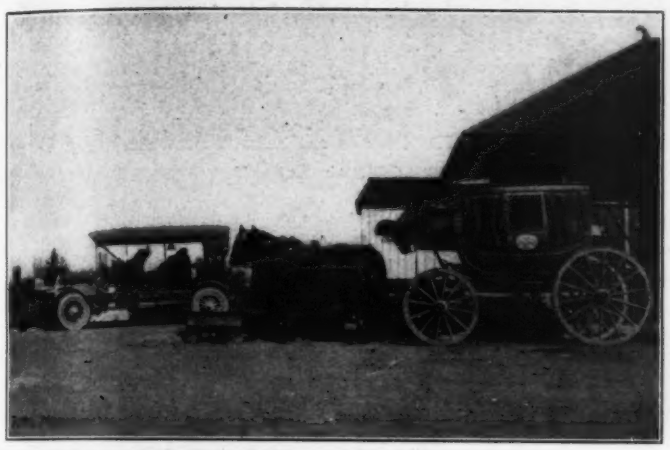
We are very much surprised to see in your issue of June 8, in the article contributed by Mr. H. Raynar Wilson, a statement to the effect that the extensions to the electrification system of the London, Brighton & South Coast Ry. have been carried out by the Allgemeine Elektricitats Gesellschaft.

This statement is entirely incorrect, as the whole of the overhead, switch gear and cable work has been carried out by Robert W. Blackwell & Co., Ltd., as direct contractors to the railway company.

As you draw particular attention to the notable record of 46½ miles of track being equipped in nine months from the placing of the orders, we think, out of common fairness to ourselves, you should correct this mis-statement.

We regret that our contributor should have failed to give proper credit to our correspondents for their part in the electrification work.

The old-time Concord stage is so rapidly disappearing that it seems worth while to print the accompanying photograph of one still in service, running between Barre and Petersham, Mass. Beside it appears its 20th Century rival, the automobile, which is undoubtedly destined to replace the horse-drawn vehicle as a public conveyance on common roads, as the power-driven car



THE OLD AND THE NEW.

has replaced the horse-car running on rails which represented the acme of progress in street transportation half a century ago. We are indebted for the photograph to Mr. F. F. Henshaw, of the U. S. Geological Survey.

The Effect of Fuel Consumption in New York City Upon Temperature and Rainfall.*

By REGINALD P. BOLTON,† M. Am. Soc. C. E.

The processes of heating and ventilating are both associated directly with the physical condition of the atmosphere, and therefore a study of any phase of science by which that great primal element is affected, would appear to be worthy of the consideration of heating and ventilating engineers. The variations of wind, of weather, of rainfall and such geographic features as affect the atmospheric envelope with which we have to deal, are subjects that come within our purview. Following this line of thought, I invite your attention to the subject of the probable effect upon the climate of a great city, of the vast quantity of heat emanating from its industries and from the heating of its buildings.

TEMPERATURE.—The lowest range of atmospheric temperatures which are to be expected in any locality are naturally those which must form the basis for the computations and estimates of the heating engineer.

It is important, therefore, for the heating engineer, to study the past records of temperatures in order to determine the maximum conditions of any locality. In New York City, our local authorities maintain hourly records of every element of atmospheric vicissitude, extending over a long period of time, and recorded under conditions of precise regularity.

It was found on examination of these records that the occurrence of a temperature as low as, or lower than zero, has been of less frequency for many years, and since 1904 has not been experienced at all. Further, that such occurrences are so infrequent and of so short a duration, that the provision for heating, under such conditions, might be provided by some excess or overcapacity of apparatus, by which means much idle investment might be saved.

This leads to the question whether the practical elimination of "zero conditions" has been effected or brought about by any artificial means. Attention is naturally further directed by the prevailing shortage of water in the Metropolitan area, to the records of humidity and precipitation, and it appears that in this element of our atmospheric surroundings some change has also taken place. On the other hand, the growth of fuel consumption and the resultant heat emitted over the area of the Metropolis, has been such that the question arises whether or not its volume has reached an extent capable of affecting atmospheric conditions.

Exact statistics of the consumption of fuel within the boundaries of the city have not been recorded for any great length of time, but sufficient indication may be gathered from those recorded during recent years to indicate that the increase in consumption has kept pace with the vast growth of the population.

The following details of the usage of coal in Greater New York are derived in part from the "Coal Trade Journal," and in part from the public records. The generation of power for transit purposes in 1909 consumed 1,343,573 tons, and the electric lighting companies consumed 884,757 tons. The production of gas involves the distillation of 918,000 tons of coal per annum, from which 450,000 tons of coke are derived, of which 188,000 tons are consumed by the gas companies, and 271,000 tons distributed and added to the domestic fuel consumed in the Greater City. In addition to the fuel, 137,000,000 gals. of oil are used for gas enrichment, or a total weight of 512,000 tons; this is equivalent in heat value to coal of a weight of 768,000 tons.

From these products there was made in 1909, an output of 36,500,000 cu. ft. of gas, which was distributed and burned within the area of the Greater City. The production and consumption of gas, therefore, is equivalent to the heat value of a total of 1,686,000 tons.

There are 50 breweries, consuming about 500,000 tons annually, and the fleets of harbor tugs and vessels are estimated to consume about 450,000 tons of bituminous coal. There are 745 private power plants in industrial hotel and business buildings consuming about 2,200,000 tons. The domestic usage of fuel, in houses, stores and apartments, is by far the largest and best defined element, amounting to 6,380,000 tons. Sundry other elements bring the present annual consumption to a total of approximately 16,932,000 net tons per annum.

A proportionate addition for the consumption in Jersey City and its vicinity, in which a population of some 340,000 persons is resident, would add 1,250,000 tons. With the addition of the oil used in gas manufacture, the total equivalent in coal becomes 18,950,000 tons.

The consumption of fuel has grown 23% in five years, and its course is shown in Fig. 2, on which is also shown the growth of population of the Greater City; this shows a nearly parallel rate of increase, doubtless due to the large proportion of fuel which is directly utilized for domestic purposes.

With these figures in hand, we can arrive at some estimation of the vast quantity of heat communicated to the incumbent atmosphere, particularly during the heating season. From all the sources above described, there is cast up into the atmosphere a volume of heated gases, at an average temperature of fully 350° F., probably 18 times in weight that of the fuel consumed.

To this volcano of heated gases is added all the exhausted steam, and the products of combustion of gas, all mingling directly with the atmosphere, and in addition the radiant heat and heat conveyed by convection from all buildings, all frictional sources, and dissipation of energy. The heat of condensed steam in power houses and that of all sewage is communicated to the waters within the area of the city, and is thus indirectly added to the heat-radiating effect.

A not inconsiderable item is that of the animal heat of the population of 5,000,000 persons, which, upon the basis of an average emission of 200 heat units per hr. per individual, would amount to 24,000,000,000 per diem, equivalent to the heat value of 438,000 tons of coal per annum.

The portion of the city in which the fuel consumption takes place is practically that included within an area of 130 sq. mi. Within this area, during the winter heating season, about 80% of all the fuel, and about 60% of the oil is consumed. The average consumption of 85,830 tons per day, upon the basis of an average temperature of 40°, leads to the extreme condition, when

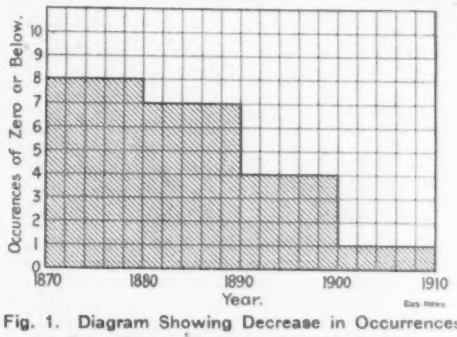


Fig. 1. Diagram Showing Decrease in Occurrences of Zero Temperature at New York City.
(Last occurrence, Jan. 5, 1904.)

a zero temperature is approached, of a consumption of 214,560 tons per day.

We may first consider the effects of the emission from the smoke flues and stacks of the gases derived from their combustion of this amount of fuel. Assuming the emitted gases to be 18 times the weight of fuel burned, their daily volume would be 175,680,000,000 cu. ft., and if their average temperature be taken as 350° F., the heat contained would be 614,500,000,000 heat-units. Such a heated volume would add 3½° to the temperature of the atmosphere, for half a mile in height, over the area of 130 sq. miles.

If to the volume of these gases of combustion, we add the radiant heat and that imparted by convection from all sources to which reference has been made, we find a total exceeding 4,000,000,000 heat units per 24 hrs., which may be capable of increasing by a similar amount the temperature of a volume of air seven times greater than the foregoing, or would raise the temperature 4.94° F. over the entire area of the Greater City, 326 sq. mi., to a height of a mile.

It would seem, therefore, that the first premise as to the effect of the heat emitted by the city in

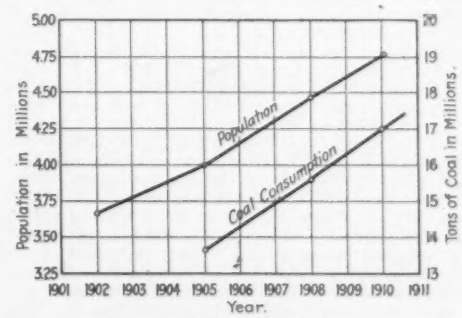


Fig. 2. Diagram Showing Relative Increase of Population and Fuel Consumption in New York City: 1901-1911.

modifying the lowest temperatures of the winter season, is substantiated.

PRECIPITATION.—That this great emission of heat is also capable of producing some effect upon rainfall appears from the conditions disclosed by the records of precipitation.

The mean annual rainfall of the City of New York is 44.6 ins., an average which, up to 1903, was fairly maintained, the average for 25 yrs. prior to that date being nearly 45 ins. Since 1903, however, the mean precipitation has fallen to 40.17, and the highest annual rainfall in that period, 1907, was only 45.48 ins. (Fig. 3). At the same time the number of cloudless days has considerably increased. Between 1889 and 1903, the highest number of such occurrences was 96; but since 1903 the highest has risen to 114, and the average for seven years has been 101.

These are indications of a growing condition of dryness which appear to accompany a decrease in annual precipitation, which in 1910 fell to the unusually low rate of 33.72 ins. Examination of the precipitation during the heating season shows that there has been a progressive decrease dur-

*Abstract from the presidential address at the semi-annual meeting of the American Society of Heating and Ventilating Engineers, at Chicago, July 6.

†Consulting Engineer, 527 Fifth Ave., New York, N. Y.

ing the past 20 years, and since the winter rains are those which are least subject to evaporation, their reduction is likely to be productive of the condition of dryness from which New York is at present suffering.

Assuming that the large volume of heat already described should be added to the incumbent atmosphere over the area of the city, or 326 sq. miles; for each degree added, the increased temperature of the air would add about 3½% to the moisture-absorbing capacity of the atmosphere. It is evident that this great volume of heated air would, in the absence of wind, rise as

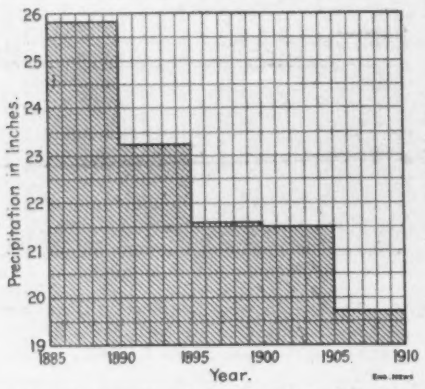


Fig. 3. Diagram Showing Decrease in Precipitation During Winter Months at New York City Since 1884.

do the gases emitted from the mouth of a volcano, and reaching a certain height, would spread and fall as they were gradually cooled by the cold blanket of super-incumbent air or moisture-laden clouds. The effect would thus radiate over a very considerable area, and would be productive of just such a variation of the conditions of humidity in the city and its surrounding district as appears from the records to have been gradually developing.

So far as the rise of temperature is concerned, no other than beneficial results can be attributed to the dissipation of this vast amount of heat, but if the effect extends, as it must extend, into the absorption of moisture by the air which would otherwise have been deposited upon the area below it, then we shall find, in a reduction of winter rainfall over this area, a result which may have reached an appreciable point at the present time, and which, in the course of time, by the growth of the interference with nature, may become disastrous.

That such an effect is now going on, would appear reasonable from the premises. The total heat emitted would raise the moisture-absorbing capacity of an envelope of air a mile high over an area of 326 sq. mil. about 7½%. Let us assume that the usual conditions preceding a rainfall are in progress, A gathering amount of humidity in the superincumbent atmosphere has taken place, and a degree of saturation has been reached, of, say, 99%, the temperature of the air being 42° F. At the approach of any cooler wind or other layer of air, the temperature would fall, and upon reaching 40°, a condition of complete saturation would be reached and rain would commence.

But meantime, the heat emitted by the city below is being continuously transmitted to, or radiated through the atmosphere below the rain clouds; and notwithstanding the fall in temperature of the superincumbent layers, the rising column of heat has the power of increasing the absorbing capacity of the layer below, or of retarding the fall in temperature of the saturated air, so that the dew point is not reached. Under these circumstances, rain will not fall, though the atmosphere (for some distance above the ground) may be highly saturated, in which form it will remain as a fog.

The figures cited indicate that the total heat emitted by the city in average winter temperature of 40° F. would add to the temperature 2° over the area of the Greater City, 326 sq. mi., to a height of one mile, and would produce the effect of increasing the capacity for saturation of the mass of 48,000,000,000,000 cu. ft. by a total of 1,440,000,000 lbs. of water—equivalent to about 0.03-in. of rain over the entire area of the city.

If these conclusions as to the association of the mechanical dissipation of heat with the vicissitudes of temperature and humidity in the surrounding atmosphere should be well based, then we must look forward to an increasing degree of artificial interference with the course of nature as the population and its fuel consumption grow on parallel lines.

FIG. 1. VIEW FROM NEAR THE SWITCH TOWER LOOKING EAST TOWARDS BRIDGEPORT.

The Wreck of the Federal Express on the New York, New Haven & Hartford R. R., Near Bridgeport, Conn.

The accompanying illustrations are reproduced from photographs taken immediately after the fatal Bridgeport disaster of July 11, which was briefly described in our last issue. The plan of the tracks was drawn from plans on file with the City Engineer of Bridgeport, Mr. M. F. McKenna.

It appears from information not available when our last issue went to press that the cross-over switch was in the same location it has been in for ten years past and that the engine-runner of the train, while not the regular engineer, was a man of thorough experience, familiar with the road from many years running.

We are now able to state that the cross-over switch was interlocked with a high semaphore signal located about 100 ft. from the signal tower and in full view, therefore, of the towerman. A distant signal is also interlocked with the home and is located about 2,400 ft. west of the signal tower. An engine-runner approaching comes around an easy curve and into view of the home signal when within about 1,500 ft. of it. Besides the semaphore, low dwarf signals are also placed beside each switch of the cross-over.

The derailment occurred at the cross-over shown by the pointer in the plan, Fig. 4. The speed of the train at this point must have been close to 60 miles per hour. The frogs at the cross-over are No. 10.

Fig. 1 is a general view of the wrecked train looking east from a point near the switch tower. Fig. 2 was taken from a point near the east end of the Fairfield Ave. bridge looking west. This picture shows clearly the damage to the bridge. The outside plate girder was entirely cut away from the floor-beams and the whole track forced off the ends of the floor-beams. Fig. 3 gives a closer view of the wreckage showing the remains of the day coach and the overturned Pullman sleeping car in which most of the casualties occurred.

The plan, Fig. 4, makes clear how any derail-

FIG. 2. VIEW OF THE FAIRFIELD AVE. BRIDGE, SHOWING OUTSIDE PLATE GIRDER TORN AWAY, LOOKING WEST.

ment at this cross-over was likely to result seriously. The cross-over is located just west of an open floor girder bridge, east of which is a fill between high vertical walls, with a factory siding on a 1.5% down grade but a short distance farther east. Under these circumstances

FIG. 3. VIEW LOOKING WEST; WRECKAGE OF THE DAY COACH IN FOREGROUND.

the chance of the derailed train remaining on the roadbed was small.

The accident is now being investigated by a coroner's jury and by special agents of the Interstate Commerce Commission. Press reports also state that the newly created Public Utilities Commission of Connecticut will conduct an investigation as soon as appointed.

A Prize for Essays on Naval Subjects is offered by the United States Naval Institute, according to an announcement in the June "Proceedings" of the Institute. The notice, signed by Prof. Philip R. Alger, U. S. N., Annapolis, Md., as Secretary and Treasurer of the Institute, is as follows:

A prize of $200, with a gold medal, and a life-membership in the Institute, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules:

1. The award for the prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.
2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before Jan. 1, 1912. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.
3. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.
4. If, in the opinion of the Board of Control, the best essay presented is not of sufficient merit to be awarded the prize, it may receive "Honorable Mention" or such other distinction as the Board may decide.
5. In case one or more essays receive "Honorable Mention," the writer of the first of them in order of merit will receive $75 and a life-membership in the Institute.
6. Any essay not having received honorable mention may be published also, at the discretion of the Board of Control, but only with the consent of the author.
7. The essay is limited to 50 printed pages of the Proceedings of the Institute.
8. All essays submitted must be either typewritten or copied in a clear and legible hand.
9. In the event of the prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of the gold medal.

It does not appear from the above that the competition is limited to members of the Naval Institute.

Research as a Financial Asset.*

By WILLIS R. WHITNEY,† Past Pres. Am. Chem. Soc.

For some reasons it may be thought unfortunate that so large a proportion of man's energies should be devoted solely to the industries. In some eras we find that there was a predominance of art over industry; in others, literature was predominant; in still others, war and conquest. Once territorial discovery and acquisition predominated, and now, in our own times, the principles of community interest have so greatly developed that we are accustomed to seeing many people who, instead of directly producing their own necessities of life, are more generally repeatedly producing some one little article which contributes to the lives of others. This we recognize as a natural tendency to higher efficiency. Our intricate and delicately balanced system of work is becoming continually more complex, but is certainly still covered by the elemental laws of demand and of survival. New discoveries in our day are largely mental, instead of geographical, and the old battles of conquest have become wars with ignorance. They are struggles to overcome inefficiencies, attempts to broaden the common mental horizon, as our ancestors broadened their physical horizon. Very few people realize the rapidity with which technical advances are being made. Few realize how the way of this advance has itself advanced.

Complex development is largely responsible for research laboratories. A research laboratory is a place where men are especially occupied with new problems, presumably not too far in advance of technical application. By this group devoting its entire attention to the difficulties of meeting already well-defined necessities, or of newly defining and meeting together, the efficiency of those processes is increased. Men specially trained for this very purpose are employed and they are usually just as unfitted for successfully manufacturing as those who efficiently reproduce are of discovering or inventing. It is merely an extension of the principle of the maximum efficiency. A man with his entire attention devoted for months or years at a time to the difficulties of a single problem should be better able to reach a solution than the man who can devote only irregular intervals to it. He should then also be the better prepared for a second problem.

A research laboratory is also a place equipped with apparatus especially designed for experimental work. In a busy manufacturing plant, if a foreman has an idea pointing towards an improvement of his product he frequently has great difficulty in finding the time, the necessary idle apparatus, the raw materials and the incentive to try it. In the laboratory all of these are combined and there is added a system of cooperation of permanently recording results and an atmosphere of research.

The mathematics of cooperation of men and tools is interesting in this connection. Separated men trying their individual experiments contribute in proportion to their numbers, and their work may be called mathematically additive. The effect of a single piece of apparatus given to one man is also additive only, but when a group of men are cooperating, as distinct from merely operating, their work raises with some higher power of the number than the first power. It approaches the square for two men and the cube for three. Two men cooperating with two different and special pieces of apparatus, say a special furnace and a pyrometer, or an hydraulic press and new chemical substances, are more powerful than their arithmetical sum. These facts doubtless assist as assets of a research laboratory.

When a central organization, such as a laboratory, has access to all parts of a large manufacturing plant and is forced sooner or later to come into contact with the various processes and problems, the various possibilities and appliances, it can hardly fail to apply, in some degree, the above law of powers.

As a possible means of illustrating the almost certain assistance which one part of a manufacturing plant may give another when they are connected by experimenting departments or research laboratories and how one thread of work starts another, I will briefly review part of a single fairly connected line of work in our laboratory. In 1901, the meter department wanted electrically conducting rods of a million ohms resistance. These were to be ¼-in. diameter by 1 in. length. In connection with this work we had to become fairly familiar with published attempts at making any type of such high resistances. Some kind of porcelain body containing a very little conducting material seemed a fair starting formula after the resistance of almost all kinds of materials had been considered.

Our own porcelain department was of great help in showing us how to get a good start. We learned how and what to mix to get a fair porcelain, and we found that small quantities of carborundum or of graphite would give us the desired resistance about once in a hundred trials. The rods could be made, but the difference in their resistance when taken from the porcelain kiln and when they were made as nearly alike as we could make them, was often so many thousand-fold that something new had to be done to make a practical success. A small electric furnace was then devised for baking the rods and this was so arranged that the rate of rise of temperature, the maximum temperature reached and the duration of heat at any temperature was under control and was also recorded. The desired result was obtained and this work was thus finished. It gave us a certain stock of knowledge and assurance.

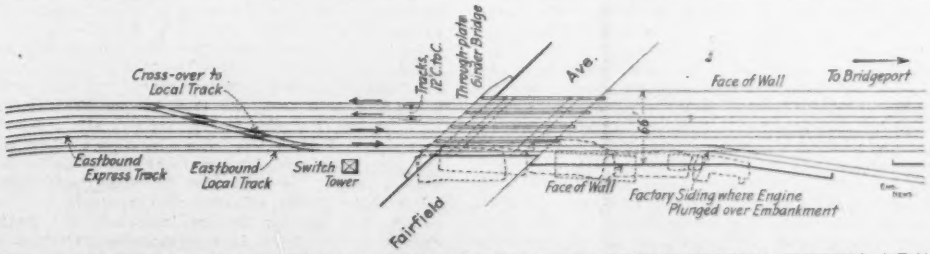


FIG. 4. SKETCH PLAN OF TRACKS; SITE OF THE WRECK OF THE FEDERAL EXPRESS, NEW YORK, NEW HAVEN & HARTFORD R. R., NEAR BRIDGEPORT, CONN.

At that time a very similar problem was bothering one of the engineering departments. Lightning arrester rods, part of the apparatus for protecting power lines from lightning, were needed. Their dimensions were ¾ × 6 ins. and they needed to have a definite but, in this case, low resistance, and could apparently not be baked in a porcelain kiln. The usual temperature variations in such a kiln are so great that in practice many thousand rods were repeatedly fired and afterward tested to yield a few hundred of satisfactory product. All the cost of making an entire batch would have to be charged against the few units which might be found satisfactory, and in many cases there were none good in a thousand tested.

It was evident that regulation and control of temper-

*From an address at the Fiftieth Anniversary of the Granting of the Charter of the Massachusetts Institute of Technology, Boston, Mass.

†Director, Research Laboratory, General Electric Co., Schenectady, N. Y.

ature was necessary. This was found to be impracticable in case any considerable number were to be fired at one time, as the heated mass was so great that the rods near the walls of the retort received a very different heat-treatment from those near the middle and were consequently electrically different. This was still the case even when electrically heated muffles were used. This difficulty led to experiments along the line of a heated pipe, through which the rods could be automatically passed.

Some time was spent in trying to make a practical furnace out of a length of ordinary iron pipe, which was so arranged as to carry enough electric current to be heated to the proper baking temperature. Troubles here with oxidation of the iron finally led to substitution of carbon pipes. This resulted in a carbon-tube furnace, which is merely a collection of 6-ft. carbon pipes, embedded in coke powder to prevent combustion and held at the ends in water-cooled copper clamps, which introduced the electric current. By control of this current, the temperature could be kept constant at any point desired. When this was combined with a constant rate of mechanical feed of the air-dried rods of porcelain mixture, a good product was obtained. For the past seven years, this furnace has turned out all the arrester rods, the number produced the last year being over 100,000.

In this work we were also forced to get into close touch with the electroplating department. The rods had to be copper-plated at the ends, to insure good electrical contact. The simple plating was not enough. This introduced other problems, which I will pass over, as I wish to follow the line of continuous experiment brought about, in part, at least, by the single investigation.

The electric furnace consisting of the carbon tube packed in coke was a good tool for other work, and among other things we heated the carbon filaments for incandescent lamps in it. We were actuated by a theory that the high temperature thus obtainable would benefit the filament by removal of ash ingredients, which we knew the ordinary firing methods left there. While these were removed, the results did not prove the correctness of the theory, but rather the usefulness of trying experiments. It was found by experiment that the graphite coat on the ordinary lamp filament was so completely changed as to permit of a hundred per cent. increase in the lamp life or over 20% increase in the efficiency of the lamp for the same life, so that for the past four or five years a large part of the carbon lamps made in this country have been of this improved type. This is the metallized, or "gem" lamp.

Naturally, this work started a great deal of other work along the lines of incandescent lamp improvement. At no time has such work been stopped, but in addition to it, the new lines of metallic filament lamps were taken up. In fact, during the past five or six years, a very large proportion of our entire work has been done along the line of tungsten incandescent lamps. In this way we have been able to keep in the van of this line of manufacture.

The carbon tube furnace has been elaborated for other purposes, so as to cover the action under high pressures and in vacuum. Particularly in the latter case a great deal of experimental work has been carried out, contributing to work such as that connected with rare metals. In such a furnace, materials which would react with gases have been studied to advantage.

Our experience with metallized graphite led to production of a special carbon for contact surfaces in railway-signal devices, where ordinary carbon was inferior, and suggested the possibility of our contributing to improvements in carbon motor and generator brushes. On the basis of our previous experience and by using the usual factory methods, we became acquainted with the difficulties in producing carbon and graphite motor brushes with the reliability and regularity demanded by the motor art. Furnace-firing was a prime difficulty. Here again we resorted to special electrically heated muffles, where the temperatures, even below redness, could be carefully controlled and automatically recorded. This care, aided by much experimentation along the line of composition, of proportionality between the several kinds of carbon in the brush, etc., put us into shape to make superior brushes. The company has now been manufacturing these for a couple of years, with especial reference to particularly severe requirements, such as on railway motors. In such cases the question of selling price is so secondary that we can and do charge liberally for delicacy and care of operation in the manufacture.

This carbon work naturally led to other applications of the identical processes or materials. Circuit breakers, for example, are now equipped with a specially hard carbon contact, made somewhat as motor brushes are made.

It is not my intention to connect all of the laboratory work to the thread which seemed to connect these particular pieces of work, but rather to show the possible effect in accumulating in a laboratory experiences which might affect an inventory.

Among other considerations which appeal to me is one which may be worth pointing out. Probably almost every manufacturing plant develops among its workmen, from time to time, men who are particularly endowed with aptitude for research in their line. They are usually the inventors of the company. They are often discoverers in spite of opposition. They are always trying new things. They are almost of necessity somewhat inefficient in the routine production. In many plants they are merely endured, in a few they are encouraged. To my mind their proper utilization is a safe investment. A research laboratory assists in such a scheme. Sooner or later such a laboratory becomes acquainted with this type of men in a plant and helps them in the development of their ideas.

It is not a perfectly simple matter to measure the value of a research laboratory at any one time. In the minds of some, the proper estimate is based on the profit already earned through its work, which otherwise would not have been earned by the company. This is a fair and conservative method which in our generation ought to be satisfactory when not applied too early to the laboratories. It does not take into account what we may call the good-will and inventory value, both of which should be more rapidly augmenting than any other part of a plant.

The experience and knowledge accumulated in a general research laboratory is a positive quantity. In our own case we expended in the first year not far from $10,000, and had little more than expectations to show for it. Our expenses rapidly rose and our tangible assets began to accrue. Perhaps I can point to no better criterion of the value of a research laboratory to our company than the fact that its force was rapidly increased by a company which cannot be particularly interested in purely academic work. Our annual expenditures passed the $100,000 mark several years ago. My own estimate of the value would probably be greater than that of others, for I am firmly convinced that proper scientific research is practically required by the existing conditions of our technical age.

In the case of our metallized carbon filament, which has now been in use several years, the efficiency of the light was increased by about 20%. Among the carbon lamps of last year these were sold to the extent of over $1,000,000.

A broader, but less accurate impression, may be gained by considering the economy now possible on the basis of our present incandescent lamp purchases in this country and that which would have resulted if the lamps of only ten years ago were used in their stead. On the assumption that the present rate of lamp consumption is equivalent to about 80,000,000 25-watt tungsten lamps per year, and on the basis of 1.25 watts per c. p. as against 3.1 of the earlier lamps and charging power at 10 cts. per KW.-hr., we get as a result a saving of $240,000,000 per year, or two-thirds of a million per day. Naturally, this is a saving which is to be distributed among producers, consumers and others, but illustrates very well the possibilities. It is interesting to note that we are still very far removed from a perfect incandescent illuminant, when considered from the point of view of maximum theoretical light efficiency.

I see from advertisements that 65,000 magnétite-arc lamps, originally a product of the laboratory, are now in use. These must have been sold for something near $2,000,000. The supplying of electrodes which we make and which are consumed in these lamps should amount to about $60,000 per year.

Our study of the properties of the mercury-arc produced our rectifier, which has been commercially developed within the past few years. Of these, about 6,000 have been sold. As they sell for not far from $200 per set, it is safe to say that this also represents a sale of over $1,000,000. The advantage of these outfits over other available apparatus must also be recognized as not far from $200 for each hour through which those already sold are all operating.

In such a complex field as insulations and molded materials there have been many changes produced. As far back as 1906 we were using annually, in a certain apparatus, 30,000 specially drilled and machined soapstone plates, which cost $1.10 each. As the result of experiments on substitutes for such material, it was found that they could be molded by us in the proper shape, with holes in place and of a material giving increased toughness, at a greatly reduced cost. As the result of this fact, the price of the purchased material was reduced to us from $1.10 to 60 cts. which in itself would have paid for the work. But further developments proved that the new molded material could be made for 30 cts., which the foreign material could not equal, so we have since produced it ourselves. This caused a saving of approximately $24,000 annually for this one molded piece.

In considering the research laboratory as a financial asset there is another view which might not be visible at first sight. It is the question of the difference between the value of the useful discovery when purchased from competitors in the business and when made by one's own company. It is not usually pleasant to have to purchase inventions after their value is known, no matter from whom, but to have to pay a competitor for such a discovery is doubly irksome. He naturally unduly questions its value to the competitor, and he, in turn, is overestimating another's power to use it. The purchaser's profit is apparently limited to the differences between his efficiency of operating it and that of the original owner.

I was recently informed by an officer of another large manufacturing company, where much chemical work is done and which established a research laboratory several years ago, that the most important values they got from their laboratory was the assurance that they were keeping ahead and are at least prepared for the new, if they cannot always invent it themselves. Incidentally, he said that from one part of their research work they had produced processes, etc., which had saved $800,000 a year. They are at present spending in their several research departments a total of about $300,000 a year.

We hear frequent references to the German research laboratories, and a brief discussion may be in place. For the past fifty years that country has been advancing industrially beyond other countries, not by new opened territories, new railroads, new farm lands, new water-power sites, but by new technical discoveries. In fact, this advance may be said to be largely traceable to their apparent overproduction of research men by well-fitted universities and technical schools.

Every year a few hundred new doctors of science and philosophy were thrown on the market. Most of them had been well trained to think, to experiment, to work hard, and to expect little. The chemical manufactories began to be filled with this product and it overflowed into every other calling in Germany. These well-educated young men became the docents, the assistants and the professors of all the schools of the country. They worked for $300 to $500 per year. They were satisfied so long as they could experiment and study the laws of nature, because of the interest in these laws instilled into them by splendid teachers.

This condition soon began to make itself manifest in the making of new things—all sorts of chemical compounds, all kinds of physical and electrical devices. I might say that pure organic chemistry at this time was academically most interesting. Its laws were entrancing to the enthusiastic chemist and consequently very many more doctors were turned out who wrote organic theses than any other kind. What more natural than that organic chemistry should have been the first to feel the stimulus? Hundreds, and even thousands of new commercial organic products are to be credited to these men and to that time. All the modern dyestuffs are in this class. Did Germany alone possess the raw material for this line? No! England and America had as much of that. But Germany had the prepared men and made the start.

It seems to me that America has made a start in preparing men for the research work of its industries. For example, it is no longer necessary to go abroad to get the particular training in physical chemistry and electro-chemistry which a few years ago was considered desirable. Advanced teaching of science is little, if any, more advanced in Germany to-day than it is in this country. In my opinion the quality of our research laboratories will improve as the supply of home-trained men increases, and that the laboratories of this kind will be increasingly valuable when analyzed as financial assets. I am certain, too, that the industries will not be slow in recognizing the growing value of such assets. They merely want to be shown.

Probably in most industries there are what I may call spots particularly vulnerable to research. For example, the efficiency of steam boilers, based upon the heat energy of the coal used and the efficiency of the engine using the steam, are continually being raised. We may expect, until the maximum calculable efficiency is reached, that this advance will continue. The reason is not far to seek. It is a vulnerable spot; improvement is possible; a small increase in efficiency of power plant is an ever-continuing profit. Great numbers of steam power plants exist and so inventors are influenced by the fact that new improvements may result in enormous total economies.

Artificial light is still produced at frightfully poor efficiency. Electric light from incandescent lamps has been greatly improved in this respect, but there is still room for greater economies. It is still a vulnerable spot.

In the case of iron used in transformers, we have another such vulnerable spot. A transformer is practically a mass of sheet iron, wound about with copper wire. The current must be carried around the iron a certain number of times and the copper is chosen because it does the work most economically. No more suitable material than copper seems immediately probable, nor is there any very promising way of increasing its efficiency, but in the iron about which it is wound there is a vulnerable spot. The size of the iron about which the copper is wound may possibly be still much further reducible by improvements in its quality. In other words, we do not yet know what determines the magnetic permeability or the hysteresis of the iron, and yet we do know that it has been greatly improved

in the past few years and that it can still be greatly improved.

So long as motors burn out, so long as subways are tied up by defective apparatus, so long as electric motors can run too hot, so long as street cars may catch fire from so-called explosions of the current, so long as the traffic of a whole city can be stopped by a defective insulation or a ten-cent motor brush, there will probably be the equivalent of research laboratories somewhere connected with the electrical industries, where attempts will be continually made to improve.

Notes From Engineering Schools.

RENSSELAER POLYTECHNIC INSTITUTE.—The Pittsburg Building was presented to the Institute by the Alumni Association of Pittsburg on Alumni Day, June 13. On the same day it was announced that the Class of '87 had presented $150,000 for a new gymnasium, to be completed by 1912.

UNIVERSITY OF ILLINOIS.—The Illinois Legislature, which recently adjourned, appropriated for the support of the State University for two years following July 1 the sum of $3,500,000, of which about $500,000 is for new buildings. The College of Engineering received specific appropriations for maintenance amounting to $192,000 in addition to $200,000 for a building. The Department of Mining Engineering received appropriations of $35,000 for maintenance and $25,000 for equipment. The Legislature also authorized a tax of 1 mill upon the assessed value of the State for the future support of the University.

COLUMBIA UNIVERSITY.—New graduate courses in highway engineering will be offered next fall under Prof. A. H. Blanchard, M. Am. Soc. C. E., who was until recently Associate Professor of Civil Engineering at Brown University and Deputy Engineer of the State Board of Public Roads of Rhode Island. These courses are to be designed for technical graduates who have already had a four-years' course in civil engineering.

As many highway engineers are not particularly busy during the winter months from Dec. 1 to April 1, it is expected that many will take advantage of these courses to perfect themselves along lines in which they have already had some experience. These courses are to fit technical graduates who are attracted to highway work for the highway departments of cities, towns, states, counties and parks; the engineering organizations of contractors, and the engineering and sales departments of companies dealing in materials and machinery used in highway work.

The new graduate courses to be offered at Columbia will cover the subjects necessary to meet these ends. The period of attendance will be from December to March inclusive, equivalent to about one semester. Two periods of residence will be required for a Master's Degree. The tentative arrangement of these courses is as follows:

FIRST YEAR.

Processes of Industrial Chemistry.
Dynamical and Structural Geology,
Advanced Highway Engineering,
Materials of Highway Engineering,
Seminary in Current Highway Engineering Literature,
Lectures by Highway Engineers, Chemists and other Experts,
Mechanical Appliances Used in Highway Engineering,
Highway Bridges and Culverts,
Road Surveying, Drafting and Designing.

SECOND YEAR.

Industrial Chemical Laboratory,
Lithology, Petrology and Petrography,
Advanced Highway Engineering,
Highway Laws and Systems of Administration,
Seminary in Current Highway Engineering and Literature,
Lectures by Highway Engineers, Chemists and other Experts,
Road Material Laboratory,
Management Engineering,
Street Surveying, Drafting and Designing.

A special staff of instructors has been appointed and laboratories will be completely equipped for the work outlined above. It is the hope of those interested in the higher education of highway engineers in the United States that it will be possible in the near future to lay the foundation for the establishment of a corps of highway engineers comparable to that admirable body of trained men who have graduated from l'Ecole Nationale des Ponts et Chaussées of France.

A Coal Mine Explosion at Sykesville, Pa., July 15 in the Cascade Coal & Coke Co.'s mine killed 21 miners. The damage to the mine was slight. Reports state that most of the victims were asphyxiated.

A Powder Mill Explosion involving about 3,000 lbs. of nitroglycerine took place at the Du Pont plant 15 miles south of Denver, Colo., July 17. One man was killed and two others were reported missing. Two buildings were destroyed.

A Collision on a Trestle, leading to the Soo ore docks, in Superior, Wis., July 12, between an ore train and a freight train, is reported to have caused the death of 20 men. Reports state that the trestle was destroyed by fire which started in the wreckage.

Forest Fires in northern Ontario July 11 swept through the Porcupine mining district causing heavy damage to mines and a loss of life variously estimated at from 50 to 300. Reports state that the mines reached by the flames included the Dome, North Dome, Preston, East Dome, Vipond, Foley-O'Brien, Philadelphia, United Porcupine, Standard, Imperial, Success and West Dome. Many people saved their lives by taking to the lakes and many were drowned by the swamping of overloaded boats and canoes. The towns of Cochrane, Pittsville and South Porcupine were destroyed.

In the northeastern part of Michigan's Southern Peninsula, forest fires of July 11-14 inflicted a heavy loss. Au Sable, Oscoda, Metz, Posen, Larocque and Tower—all small towns or villages—were reported as entirely destroyed, but without loss of life. The city of Alpena was damaged to the extent of $1,000,000. There is some disagreement in the press reports as to whether the first two towns named were destroyed by forest fires or simply a conflagration originating in a lumber yard. Conditions were much improved July 14 by a heavy rain.

Several fires were reported in the forests of Maine July 10. The most extensive was in Enchanted township, 15 miles south of Jackman in Somerset Co., where an area of about 10,000 acres was burned over.

A Derailment in Germany July 17 caused the death of eleven persons and the injury of many others. The through express from Basel, Switzerland, for Berlin was entering the station at Mullheim, Baden, Germany, when the locomotive left the rails. Four coaches followed it and were telescoped.

Rail Expansion Caused a Wreck on the Oregon Trunk R. R. July 10 near The Dalles, Oregon. The rails were thrust sideways, or kinked, at one point enough to derail the locomotive of a southbound passenger train. The locomotive and one day coach rolled down a 40-ft. embankment. One man was killed and 20 other persons were severely injured. This accident was similar in cause to one explained by Mr. T. G. Dabney in a letter published in Eng. News, June 10, 1909, p. 633.

The Steamship "Irma," a vessel of about 3,000 tons, was sunk last week in the estuary of the San Juan River near the Nicaragua-Costa Rica boundary by collision with the "Diamante," a slightly larger boat owned by the Deutsch-Amerika Co. of Hamburg, Germany. The accident occurred during a violent storm when most of the passengers were below decks. The "Irma" went down very quickly and about 35 persons were drowned. The "Diamante" was badly damaged at the bow but remained afloat.

The lake steamer "John Mitchell" was sunk July 9 off Vermilion Point west of Sault Ste. Marie, Mich., by collision with the "Wm. H. Mack." The collision occurred at night. Reports state that 27 persons were drowned. The "Wm. H. Mack" was heavily damaged at the bow. The "John Mitchell" is owned by C. W. Elpicke & Co., of Chicago, Ill.

Chimneys Founded on Caissons are to be constructed for the State Capitol power-house at Albany, N. Y. There are to be two 200-ft. brick stacks, 15 ft. 6 ins. base diameter and 9 ft. 2 ins. top diameter. Each stack will rest on a cylindrical caisson 18 ft. in diameter by 65 ft. deep, carried to rock. The contract for these caissons has just been let. The work is under the supervision of Mr. F. B. Ware, State Architect, and Mr. T. K. Thompson, Engineer. (The Foundation Co., 115 Broadway, New York, contractors for the caissons.)

The Cofferdam Around the "Maine" was pumped down to a level of 18 ft. below the harbor level on July 18, according to press dispatches. These same reports also state that soundings show nowhere in the cofferdam a depth in excess of 4 ft. and that large areas of mud now show above the 18-ft. level. This report does not accord with the soundings taken before the work was undertaken, for they recorded the bottom at an elevation 37 ft. below water level.

A New Highway Commission for the state of New York is provided for in a bill signed by Gov. Dix on July 12. This Commission is to be made up of three men, the State Engineer and the Superintendent of Public Works, ex-officio and a new official to be known as the State Superintendent of Highways, drawing an annual salary of $7,500. This latter official is to be the executive head of the Commission. The new Commission supersedes one established about two years ago, which consisted of three Commissioners, one of whom was an engineer, all appointed by the Governor.

A New State Conservation Commission for New York has also been established by a recent Act of the Legislature, signed on July 12 by the Governor. This Commission is to take the place of the present Forest, Fish and Game Commissioner, the State Forest Land Purchasing Board, the State Water Supply Commission and the Black River Water Power Commission. The new Commission will consist of three members, each to receive a salary of $10,000 per annum. They are to be appointed by the Governor for a term of six years. The Commission is to appoint three deputies and a secretary, each at a salary of $3,500 per annum, and a Chief Engineer and a Counsel, each at an annual salary of $7,500.

The Advisory Board of Consulting Engineers of the New York State Barge Canal is abolished by an Act of the Legislature, passed by the Assembly on May 23 and by the Senate on July 18. As this bill was introduced at the earnest solicitation of Gov. Dix, it is to be presumed that he will sign it. There will be no engineering authority on the canal work superior to the State Engineer, who has charge of its design and construction. By the wording of the Act, he may employ such consulting engineers as he may choose.

The Cross-Country Aeroplane Flight of Mr. H. N. Atwood, which was started at Boston, Mass., on June 30 (Eng. News, July 6, 1911, p. 35) was completed on July 11 by a 42-mile flight from Baltimore to the U. S. Army aviation field just outside of Washington, D. C. The last legs of the flight, Atlantic City, N. J., to Baltimore and Baltimore to Washington, were held back by numerous minor accidents which required two changes in machines. The Atlantic City-Baltimore flight is the record cross-country flight with a passenger made in this country, 148 miles. In all 568 miles were covered, all but the 110 miles from Governor's Island to Atlantic City being with a passenger.

Unprecedented High Temperatures during the hot wave of July 2 to 14 made asphalt pavements very soft. The New York "Times" says:

This softness of the pavement made trucking more difficult and the pulling so much harder for horses that veterinarians say it was the indirect cause of many a horse's death.

In few streets was this condition worse than in West St. The broad asphalt plaza was like a seething sea of tar until long after the sun set. One truck owner backed his truck up against the pier and loaded them at night, that they might be ready for early delivery the next morning. When the drivers appeared next day the wheels of every truck had sunk deep into the asphalt, some being buried far above the felloe.

The drivers had to get powerful jacks to put under the hubs of the wheels, and to supplement these with four horses and their own efforts with crowbars before the vehicles were released.

A Gasoline-Engine Driven Tool Car was recently built for the Chicago, Rock Island & Pacific Ry. by the Otto Gas Engine Works, of Philadelphia, Pa. In addition to propelling the car, the gasoline engine is used when the car is at rest for driving an electric generator which supplies power for electric tools used in track work. The electric tools carried comprise spike-screwing machines, drills, a rotary rail-saw and portable grinding wheels. The grinding wheels are used for sharpening drills and other tools and for smoothing rails for bonding. The car is intended primarily to facilitate the economical driving of screw spikes.

The engine is of the four-cylinder four-cycle type with 4¼-in. bore and 4½-in. stroke. It is connected to the transmission shaft by a leather-faced cone clutch. The transmission is of the selective, sliding-gear type giving three speeds forward and reverse. The car can be run at speeds of from 10 to 40 mi. per hr. A portable turntable is provided for turning the car and removing it from the track when a prolonged stop is to be made. The generator is designed for 6.5 KW. at 1,100 r. p. m. with a voltage of 125. To eliminate the necessity of frequently moving the car, a quarter-mile of cable is carried with plug-in switches at intervals of about 20 ft. The tools can be plugged-in at the switches most convenient to their work.

Tests have shown that two men with one electric driver can drive the screw spikes as fast as three men, each using an electric tool, can drill the holes. A spike can be driven in from 1¾ to 2 seconds, as compared with 8 to 10 minutes by hand driving. The car is provided with two electric spike drivers and six electric drills. It can carry a crew of ten men.

A Public Utilities Commission, having jurisdiction over steam and electric railways, electric light, gas, water, telegraph, telephone, power and express companies, is provided for in a bill recently passed by the Connecticut legislature and signed by Governor Baldwin. The old Railway Commission is abolished. The new commission will be composed of three members with salaries of $5,000 per annum and a secretary. The commissioners must be residents of Connecticut and not officially connected with any public service corporation. A novel feature in the provisions of this law is that by which any member may be recalled. The Attorney-General of the state must start legal proceedings to remove any member when 100 voters of the commonwealth unite in a petition alleging his incompetency or misconduct. Accidents must be reported to the commission and will be investigated by it. Stocks in companies must be paid for at par, and any corporation official guilty of participating in an overvaluation in connection with new securities will be liable to a fine of not more than $10,000 or not more than 5 years imprisonment. The commission has practically the power of a court in compelling the attendance of witnesses and has full right of entry for the purposes of investigation. The commission has sweeping jurisdiction over railway rates and can fix proportional rates of connecting lines where there is disagreement; can compel the use of proper equipment and order repairs, and has the same jurisdiction over trustees and receivers as over companies, subject only to the action of the appointing court.

Personals.

Mr. August Baltzer has been appointed City Engineer of Kenosha, Wis., succeeding Mr. Robert H. Moth, resigned.

Mr. Osburn Monnett, Western Editor of "Power," has been appointed Chief Smoke Inspector of the city of Chicago, Ill.

Mr. Frederic A. Molitor, M. Am. Soc. C. E., has become associated with Mr. E. P. Goodrich, M. Am. Soc. C. E., with offices at 54 Liberty St. and 35 Nassau St., New York City.

Mr. J. F. Becheley, until recently General Superintendent of the Gulf, Texas & Western Ry., has returned to his former position as Division Superintendent of the Illinois Central R. R. at Chicago, Ill.

Mr. C. E. Brown, Assoc. M. Am. Soc. C. E., formerly Assistant Engineer of Railroad and Canal Revaluation, State of New Jersey, has been appointed Resident Engineer of the Florida East Coast Ry.

Mr. Thomas J. Ahearn, recently retired as Deputy Fire Chief of New York City on a pension of $4,200 per annum, has been nominated as State Fire Marshal of New York, by Governor Dix, at a salary of $7,000 per annum.

Mr. Theodore H. Curtis, formerly Superintendent of Motive Power of the Louisville & Nashville R. R., has been selected as Mechanical Engineer of the commission to investigate smoke abatement in Chicago, Ill., which was appointed by the Chicago Association of Commerce.

Mr. Louis C. Kelsey, M. Am. Soc. C. E., of Portland, Ore., has been appointed Consulting Engineer to the Oregon State Board of Health, to advise on matters relating to water supply, sewerage and sewage disposal.

Mr. F. G. Jonah, M. Am. Soc. C. E., whose appointment as Chief Engineer of the New Orleans, Texas & Mexico and the St. Louis, Brownsville & Mexico Rys. was announced in our issue of June 29, retains also his position of Chief Engineer of Construction of the St. Louis & San Francisco R. R. at St. Louis.

Drs. W. A. Evans and G. L. Keifer, of the Health Departments of Chicago and Detroit, respectively, have been awarded the honorary degree of Doctor of Public Health by the University of Michigan. This degree is a new one created at this university to honor men who attain eminence as public health officers.

Mr. William H. Catlin, of Portchester, N. Y., has been nominated by Governor Dix to be Superintendent of Highways of New York State, a position created under the new organization of the State Highway Commission. Mr. Catlin, according to press reports, is a prominent farmer and real estate dealer and an "efficient road builder." His salary will be $7,500 per annum.

Mr. Richard N. Durborow, formerly Superintendent of Motive Power of the Eastern Pennsylvania division of the Pennsylvania R. R., has been promoted to the position of Superintendent of Motive Power of the Pennsylvania Lines East of Pittsburg. Mr. Durborow began his service with the Pennsylvania R. R. as an apprentice in the West Philadelphia shops in 1879.

Mr. James E. Jenkins, Assoc. M. Am. Soc. C. E., formerly Engineer for the Thomas Crimmins Contracting Co., of New York City, has been appointed Construction Engineer for Grant Smith & Co. and Locker, contractors for Contract No. 66 on the water-supply pressure tunnel under New York City, from 99th St. to 14th St. He will make his headquarters at 25 W. 42d St.

Mr. H. F. J. Porter, Consulting Engineer, New York City, has been selected by the Organizing Committee of the Sixth Congress of the International Association for Testing Materials to act as its Local Secretary. The Congress will be held in the United States in the early part of September, 1912. Preparations are already in active progress, and Mr. Porter assumes his charge at once.

Messrs. Leonard Metcalf and Harrison P. Eddy, M's. Am. Soc. C. E., consulting sanitary engineers of Boston, Mass., announce that they have opened a branch office in Chicago, Ill. Mr. William T. Barnes, Assoc. M. Am. Soc. C. E., for many years one of the principal assistant engineers of the firm, will have charge of this office. For the next two months, however, during Mr. Barnes' absence, the office will be in charge of Mr. Charles W. Sherman, M. Am. Soc. C. E., Principal Assistant Engineer.

Messrs. George E. Van Kennen, of Ogdensburg; James W. Fleming, of Troy, and John D. Moore, of New York City, have been nominated by Governor Dix to be the New York State Conservation Commission, with salaries of $10,000 per annum each. Mr. Van Kennen is a lawyer and Mayor of Ogdensburg. Mr. Fleming is the present Forest, Fish and Game Commissioner, a recent appointee of Governor Dix. Mr. Moore is a graduate of Massachusetts Institute of Technology and a consulting engineer of 30 Church St., New York City.

Dr. T. C. Mendenhall, former President of Ohio State University, Superintendent of the U. S. Coast & Geodetic Survey, and President of Worcester Polytechnic Institute, has been decorated by the Emperor of Japan with the Order of the Rising Sun, the highest honor which the Japanese ruler can bestow upon a foreigner. Dr. Mendenhall was Professor of Physics at the Imperial University of Japan from 1875 to 1878. Since his resignation as President of the Worcester Polytechnic Institute in 1901, Dr. Mendenhall has made his home in Florence, Italy. He is now returning to this country by way of the East.

Obituary.

Cyrus Chambers, Jr., an inventor and prominent citizen of Philadelphia, Pa., died on July 10. Mr. Chambers was the inventor of the Chambers brick-making machine and of machines for binding and folding magazines.

Lieut. Thomas L. Ozburn, U. S. N., Chief Engineer Officer of the cruiser "Tacoma," committed suicide on board of his ship in the Brooklyn Navy Yard on July 12. He was born in Murphysboro, Ill., on March 29, 1879, and graduated from the Naval Academy at Annapolis in 1902. He leaves a widow and a four-year-old daughter.

Engineering Societies.

COMING MEETINGS.

OHIO ELECTRIC LIGHT ASSOCIATION.
July 25-28. Annual convention at Cedar Point, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

SOUTH DAKOTA ENGINEERING SOCIETY.
Aug. 23-26. Annual meeting at Deadwood, S. Dak. Secy., R. G. Culbertson, Mitchell, S. Dak.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 29-Sept. 1. Annual convention at Chicago, Ill. Secy., W. O. Thompson, N. Y. C. Car Shops, East Buffalo, N. Y.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Sept. 12-15. Annual meeting at St. Paul, Minn. Secy., Clarence R. George, Houston, Tex.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 12-15. Annual convention at Atlantic City, N. J. Secy., A. P. Dane, Boston & Maine R. R., Reading, Mass.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION.
Sept. 13-15. Annual convention at Glenwood Springs, Colo. Secy., F. D. Morris, P. O. Box 1052, Colorado Springs, Colo.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
Sept. 19-21. Annual convention at Spring Lake, N. J. Secy., N. T. Wilcox, Lowell, Mass.

MICHIGAN GAS ASSOCIATION.
Sept. 20-22. Annual meeting at Detroit, Mich. Secy., Glenn R. Chamberlain, Grand Rapids Gas Light Co., Grand Rapids, Mich.

Institute of Operating Engineers.

The first annual convention will be held in New York City, Sept. 1-3. The secretary is Mr. Hubert E. Collins, 29 West 39th St., New York City.

National Electric Light Association.

The membership on June 30 was 9,214. This is a gain of 3,478 for the past twelve months. The secretary, Mr. T. C. Martin, predicts an almost equally large increase during the coming year.

Canadian Electrical Association.

At the annual convention in Niagara Falls, Ont., June 21-23, officers were elected as follows: President, A. A. Dion, Ottawa; Vice-Presidents, R. F. Pack, Toronto; W. L. Adams, Niagara Falls, and W. L. Bird, Fort William, Ont. Mr. T. S. Young, 220 King St., West, Toronto, Ont. is Secretary.

Congress of International Association for Testing Materials.

The Organizing Committee for the Sixth Congress of the International Association for Testing Materials, 1912, has been formed with the following officers: Chairman, Prof. Henry M. Howe, Acting President of the Association; Vice-chairman, Mr. R. W. Lesley; secretary, Mr. H. F. J. Porter (1 Madison Ave., New York City); Treasurer, Prof. Edgar Marburg. The committee has already drawn general plans for the Congress arrangements, and has appointed eight committees to deal with the several phases of the detail work. The Congress is to be held in the first two weeks of September, 1912. The precise date and order of meeting are under consideration.

The South Dakota Engineering Society.

The first annual meeting of this society will be held at Deadwood, S. Dak., on Aug. 23 to 26. The excursions will include a trip to the Homestake Mine at Lead, the water-works plant and government irrigation works at Belle Fourche, and the Red Water and Homestake hydroelectric plants. The program includes the following papers: Valuation of Public Utilities, C. C. Witt; Economic Compression and Use of Compressed Air, M. W. Davidson; Pumping for Irrigation, Stein Bangs; A 50-ft. Reinforced-Concrete Bridge, C. G. McHugh; A Romance in Tunnel Building, A. B. McDaniel; Pioneer Railway Building, Samuel Denton; The Improvement of Public Institution Lands, S. H. Lea; A Comparison of Hydroelectric Gas and Steam Power, W. R. Putnam; The Commercial Side of Engineering, R. G. Culberson; Camp Life Reminiscences, J. L. Nelson; The Homestake Mine, B. C. Yates.

The society has now 32 members. President, S. H. Lea, Pierre; Vice-President, A. B. McDaniel, Vermilion; Secretary and Treasurer, R. G. Culbertson, Mitchell, S. Dak.

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